

THE SECRETORY CAPACITY OF THE ANTERIOR HYPOPHYSIS AS EVIDENCED BY THE EFFECT OF PARTIAL HYPOPHYSECTOMIES IN RATS¹

PHILIP E. SMITH

Department of Anatomy, College of Physicians and Surgeons, Columbia University

TWO TEXT FIGURES AND ONE PLATE (SIX FIGURES)

A survey of the literature in regard to the effects induced by hypophysectomy reveals that quantitatively and to an extent qualitatively there are considerable differences in the disabilities reported from this operation. Although a species difference in response may partly explain these differences, nevertheless it seems certain that they are also due to incomplete ablations. If they are even in part explainable by subtotal extirpations, and this would seem to be of such certainty as to be beyond question, the results indicate that the anterior lobe may have a sufficient secretory capacity so that but small fragments give distinct physiological effects or, if larger, they may fulfill the function of the entire lobe. Direct evidence upon this is supplied by the work on dogs. The effects consequent to total removal of the anterior lobe reported by Aschner,² Reichert, and others appeared to a lesser degree in the extirpations of Cushing and coworkers which were purposely partial ablations.

¹ Aided by a grant from the Committee for Research in Problems of Sex of the National Research Council.

² Aschner has been severely criticized, especially by English investigators (Blair Bell, Schaeffer), for not making anatomical examinations for fragments of the anterior lobe in his hypophysectomies. Although he made use of physiological observations for determining the completeness of his ablations, a reading of his paper will reveal that he also made careful anatomical searches for fragments of the gland.

In operative work upon the hypophysis in rats the high secretory capacity of fragments of the anterior hypophysis has been noted (Smith, '31). An occasional animal, in which it was known that much hypophyseal tissue had been removed, failed to develop any of the disabilities characteristic of total ablations. Others developed them only partially. It was surprising to note at autopsy the minuteness of the fragments which had given definite physiological effects.

In rats the effects of the complete extirpation of the anterior hypophysis are constant and pronounced (Smith, '27, '30). It is therefore an excellent form to use, in determining quantitatively what proportion of the anterior lobe is necessary to maintain an animal in a normal condition, what amounts give distinguishable physiological effects, and whether within these limits the severity of the disabilities are proportionate to the amount of glandular tissue present.

The observations made on an occasional unintentional partial removal in the earlier operations together with those from a later series of purposely incomplete ablations are presented in this paper. Attention is chiefly given to the effect upon general body growth, the thyroid, adrenals, and the reproductive organs. Piebald rats of the Long-Evans strain were used.

The ventral approach to the hypophysis and removal with a cannula and negative pressure, previously described, were used in these partial removals. The ablation of a definite proportion of the anterior lobe, however, proved more difficult and uncertain than its complete removal. Although its flattened dumbbell shape made it fairly easy to remove a lateral portion, chance determined whether the central 'connecting' portion was removed in part or entirely. However, a graded series has been secured, the amount of anterior hypophysis present in the series varying from 10 to 90 per cent of that of the littermate controls.

In all cases one or more animals of each litter served as unoperated controls. Weighings were made twice weekly, and body and tail lengths were taken under deep ether

narcosis at the beginning and termination of the experiment. At autopsy, the thyroids, adrenals, thymus, gonads, and the reproductive tract were weighed, fixed, and later serially sectioned. Each of the lobes of the pituitary—posterior and anterior—were weighed and fixed, if binocular examination showed that their size was sufficient to make their accurate removal and weighing possible. If too small for this, the pituitary capsule, after being fixed in situ, was either stripped from the floor of the cranium for sectioning or was left in place and sectioned together with the neighboring bone and other tissue. Serial sections of the hypophyses of these and the control animals were drawn with the camera, and planimeter measurements were made in order to determine the relative amounts of gland present. Since the absolute weight of the hypophysis of the control was taken at autopsy, the weight of the fragment in the experimental animal could be computed.

Observation of the fragments of the anterior hypophysis at autopsy with the dissecting binocular and a study of the sections have shown that in all cases the fragments were well vascularized. In vascular injections made a number of years ago more than one arteriole to the gland was found. This blood supply accounts for the fact that part of the gland can be removed without affecting the supply to the remaining portion.

No effects which could be correlated with either the partial or total ablation of the posterior hypophysis were found. This makes it unnecessary to discuss here the function of this lobe. A study of its relation to parturition and lactation has been given elsewhere (Smith, '32).

In all, twenty-one partial removals have been studied. The data from them and their littermate controls are presented in the table. Sixteen of these animals were operated during the period of active growth, the remaining five having attained nearly the adult weight at the time of the operation.

Table showing effects of partial hypophysectomy on

DESIGNATION OF RAT	EXPERIMENT BEGUN						
	Operation	Age, days	Weight, grams	Length, mm.	Age	Weight	Length
Females							
BH 674	Partial hypophysectomy	43	131	298	89	156	331
BH 676	Partial hypophysectomy	43	110	283	89	157	330
W 678	None (control)	43	101	275	89	184	346
B 650	Partial hypophysectomy	48	131	312	112	190	366
B 652	None (control)	48	131	310	112	224	375
W 651	Partial hypophysectomy	48	135	306	205	246	383
BH 648	None (control)	48	144	306	205	270	383
GH 3006	Partial hypophysectomy	49	136	300	240	240	367
GH 3005	None (control)	49	125	305	240	223	367
W 4051	Partial hypophysectomy	60	172	348	350	333	400
W 4052	None (control)	60	146	336	350	268	390
W 4034	Partial hypophysectomy	62	219	359	158	307	404
W 4035	None (control)	62	173	341	158	276	385
GH 2929	Partial hypophysectomy	64	145	327	108	162	339
GH 2927	None (control)	64	120	311	108	174	347
BH 3804	Partial hypophysectomy	85	134	343	156	202	373
GH 3805	None (control)	85	133	333	156	192	362
BH 2795	Partial hypophysectomy	104	169	337	394	222	362
G 2798 ²	Partial hypophysectomy	104	194	347	401	298	377
GH 2796	None (control)	104	173	332	401	223	373
G 3883	Partial hypophysectomy	218	236	362	482	297	
G 3885	None (control)	218	210	353	482	280	
BH 3748	Partial hypophysectomy	267	221	365	543	297	386
BH 3747	Partial hypophysectomy	267	250	372	543	345	395
BH 3746	None (control)	267	218	360	543	288	382
W 3360	Partial hypophysectomy	304	200	258	580	245	372
W 3359	Partial hypophysectomy	304	196	350	580	184	360
W 3361	None (control)	304	215	365	580	270	381
Males							
W 4065	Partial hypophysectomy	60	169	342	250	327	422
GH 4064	None (control)	60	185	348	250	426	444
W 4007	Partial hypophysectomy	57	199	347	213	232	366
B 4008	Partial hypophysectomy	57	209	348	213	460	430
W 4010	None (control)	57	190	343	213	548	449
GH 2632	Partial hypophysectomy	97	216		146	288	
GH 2627	None (control)	97	194		146	267	

¹ Computed from measurements of serial sections.² Definite adiposity. Cycles normal at first, later prolonged cornified stages.

general body growth and organ weights in rats

EXPERIMENT TERMINATED, AUTOPSY						
Days after operation	Anterior hypophysis		Adrenals	Thyroid	Gonads	Reproductive system except gonads
	Weight, grams	Percentage of control				
46	.0012 ¹	18	.0333	.0138	.0379	.270
46	.0017 ¹	24	.0316	.0168	.0515	.240
46	.0072	100	.0560	.0220	.0525	.243
64	.0063	67	.0589	.0180	.0421	.172
64	.0096	100	.0509	.0317	.0513	.515
157	.0040 ¹	45	.0630	.0170	.0360	.286
157	.0092	100	.0400	.0180	.0590	.348
191	.0041	40	.0558	.0224	.0539	.500
191	.0105	100	.0515	.0257	.0432	.436
285	.0035	32	.0430	.0203	.0336	.314
285	.0108	100	.0467	.0196	.0506	.557
96	.0048	60	.0519	.0247	.0720	.319
96	.0081	100	.0631	.0339	.0631	.575
44	.0009	11	.0307	.0156	.0241	.237
44	.0083	100	.0501	.0206	.0488	.406
71	.0023	32	.0435	.0128	.0508	.313
71	.0082	100	.0377	.0141	.0384	.352
290	.0033	36	.0402	.0207	.0408	.329
297	.0078	84	.0372	.0283	.0269	.244
297	.0092	100	.0375	.0252	.0445	.530
264	.0045	40	.0585	.0192	.0325	.400
264	.0115	100	.0615	.0191	.0525	.539
276	.0034	32	.0260	.0217	.0447	.506
276	.0095	90	.0352	.0261	.0430	.518
276	.0105	100	.0365	.0296	.0545	.737
274	.0040	36	.0415	.0152	.0503	.331
274	.0011	10	.0141	.0176	.0127	.346
274	.0110	100	.0270	.0194	.0556	.558
310	.0031	45	.0328	.0297	3.234	
310	.0068	100	.0414	.0321	3.391	
154	.0011	13	.0147	.0280	1.266	1.416
154	.0039	46	.0408	.0370	3.162	5.362
154	.0085	100	.0382	.0353	2.991	4.787
49	.0019	31	.0227	.0207	2.288	3.750
49	.0062	100	.0297	.0258	2.486	3.841

GENERAL BODY GROWTH

The absolute weights and lengths of the animals at the beginning and termination of the experiments are given in the table and the relative growth of the operated, compared to the control animals is presented graphically in figure 1. In this figure the percentage increase in weight and in body length of the operated rats, with that of the controls as 100, is plotted against the percentage of the anterior hypophysis

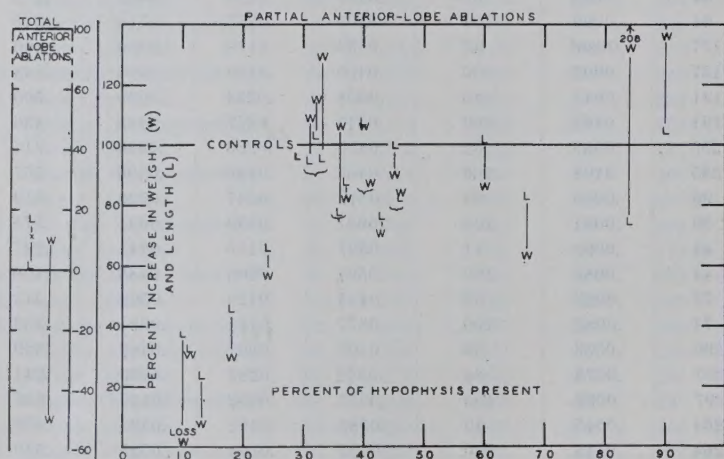


Fig. 1 At the right is shown the increase in weight (*W*) and length (*L*) in partial anterior-lobe removals and, at the left, the same data for twelve total extirpations. The percentage increase of the operated rats with that of the controls as 100 is plotted against the percentage of the anterior hypophysis present, with the weight of this gland in the respective controls as 100.

present, with the weight of this gland in each of the controls as 100. At the left of the graph, for comparison, is given the effect upon growth of the total removal of the anterior hypophysis in twelve animals. Only three of these are litter-mates of the partially hypophysectomized rats, but the ages and survival periods after operation in the others correspond closely to those partially hypophysectomized. The limits of variability of the twelve and their average ($\bar{x}$) are shown. Since in most of the complete ablations there was a loss in

weight, it was necessary, in order to indicate this loss, to have the base line in these above the level of that of the partial hypophysectomies.

The data show that the gain in general body weight and in total length was normal in those animals in which 30 per cent or more of the anterior hypophysis was found at autopsy. The five animals having less than this amount showed a

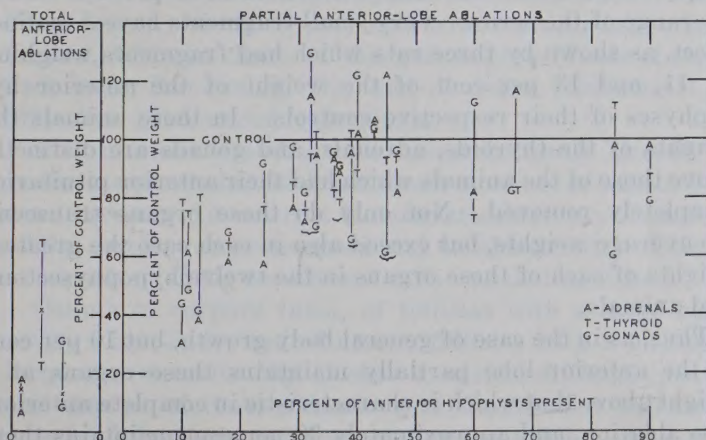


Fig. 2 At the right are shown the percentage weights of the thyroids (T), adrenals (A), and gonads (G) in the partial anterior-lobe removals and, at the left, the same data for twelve complete extirpations. The percentage weight of these glands with those of the controls as 100 is plotted against the percentage weight of the hypophysis with that of each of the controls as 100.

dwarfing which is roughly proportional to the amount of the gland present. Ten per cent of the gland (about 1 mg.) gave a growth response which seems definite.

THE THYROID, ADRENALS, AND REPRODUCTIVE ORGANS

In figure 2 the percentage weights of the thyroid, adrenals, and gonads of each of the partially hypophysectomized rats, with those of the respective controls as 100, are plotted against the percentage weight of the hypophysis with that of each of the controls as 100. At the left of the figure, for comparison,

the range of variability and average (x) weights of these glands in twelve total ablations of the anterior lobe is shown.³

As seen from figure 2, the data show that the weights of the thyroids, adrenals, and gonads fall within the normal range when 30 per cent or more of the anterior hypophysis is present. In the cases of amounts less than this, these organs are below normal in weight, their weight being roughly proportional to the amount of anterior lobe present within the range of the series. Very small fragments have a distinct effect, as shown by three rats which had fragments weighing 10, 11, and 13 per cent of the weight of the anterior hypophyses of their respective controls. In these animals the weights of the thyroids, adrenals, and gonads are distinctly above those of the animals which had their anterior pituitaries completely removed. Not only do these organs transcend the average weights, but exceed also in each case the greatest weights of each of these organs in the twelve hypophysectomized animals.

Thus, as in the case of general body growth, but 10 per cent of the anterior lobe partially maintains these organs at a weight above that which is characteristic in complete anterior-lobe ablation, and approximately 30 per cent maintains them at their normal weight.

The findings from structural studies of thyroids, adrenals, and gonads are not entirely harmonious with the findings given above. Whereas the weights of all three types of organs were affected when there was less than 30 per cent of anterior hypophysis present, such is not the case as regards structure. The structure of the thyroids appeared to be normal even in the cases with but 10, 11, and 13 per cent of

³ It will be noted that the weight of these glands is not shown, as in the case of body growth (fig. 1), as the percentage increase (or loss) during the operated period. This method would have been preferable, for, since these glands show a loss in weight after the total but not after the partial ablation of the anterior lobe, it would have shown a greater difference between these two types than is shown here. However, reference controls (animals killed at the time of operation) were not autopsied in all the litters. It is therefore only possible to show the weights of these glands in relation to the weights in the controls killed at the termination of the experiment.

the anterior lobe. A characteristic region of the thyroid of rat W 3359, having 10 per cent of the anterior hypophysis, is shown in figure 8. The epithelium is normal, being identical with that of the control and with that of a partially hypophysectomized littermate with 36 per cent of the anterior hypophysis (fig. 7). It contrasts markedly with the flattened epithelium after total hypophysectomy (fig. 17, Smith, '30). The thyroids of normal rats appear to be somewhat refractile. They do not undergo hyperplasia with anterior-lobe administration, whereas those of the guinea-pigs (Loeb et al., '30, and, later, Schockaert, '32) and of ducks (Schockaert, '31, '32) show pronounced hyperplasia.

The adrenals likewise were not structurally altered even in those animals in which but small amounts of anterior lobe were present. In contrast to complete ablations the zonation of the cortex was pronounced and no abnormality of the size or structure of the constituent cells was distinguished.

Counts of corpora lutea, of follicles with a large central cavity (figs. 3, 4), and of atretic follicles with a medium or large central cavity (fig. 4) show a marked difference between the ovaries of those animals with the smaller amounts of anterior-lobe tissue and those having one-third or more of this gland present. Figure 3 shows a section of an ovary of an animal (W 3360) with 36 per cent of anterior lobe. It does not differ significantly from that of its control (W 3361) killed at the same stage of the cycle (dioestrus). One ovary of each animal had, respectively, nineteen and thirteen large corpora, five and five large follicles, and four and three large atretic follicles. A littermate (W 3359), with 10 per cent of hypophysis, had no corpora, two large follicles, and two medium-sized atretic follicles.⁴ A similar decrease in the number of corpora of large, normal, and atretic follicles is shown by GH 2929 (fig. 5), having 11 per cent of the hypophysis, whereas BH 3804, having 32 per cent of hypophysis,

⁴No reason can be given for the absence of corpora in this animal. It has been shown that the corpora persist for long periods after hypophysectomy (Smith, '30).

gave a count similar to that of its normal control. These structural studies thus show that with the smaller fragments of anterior hypophysis there is a decrease in the number of the large normal and large atretic follicles and of corpora. Associated with this decrease is an apparent increase in the amount of interstitial tissue, although, because of the smaller size of the ovaries, this may be only relative and not actual.

The testes likewise are normal when 30 per cent of the anterior hypophysis is present. A tubule from a rat having 31 per cent of hypophysis is shown in figure 6. There is active spermatogenesis and the tubules and the testes were of normal size. In the one male having a small amount of anterior hypophysis (13 per cent, rat W 4007) the testes were small and flabby and spermatogenic activity was diminished. The defect was not as pronounced as in complete anterior-lobe ablations.

PHYSIOLOGICAL OBSERVATIONS

Definite data upon the physiological effect of the ablation of varying proportions of the anterior hypophysis were obtained as regards regularity of the sex cycles, the mating response, and reproduction. Observations upon general body vigor were also made. The latter, although not mensurable, would seem, because of the experience gained from the long handling of normal and totally hypophysectomized animals, to be definite enough to be of value.

In contrast to totally hypophysectomized rats in which cyclical changes in the vaginal smears are never present, all the animals which had a fragment of anterior hypophysis showed changes in the vaginal cell types. When less than 30 per cent of the anterior hypophysis was present, the cycles were definitely abnormal. This abnormality generally was shown by unusually long dioestrous periods, although occasionally there were also unduly long oestrous (three to four days) or post-oestrous periods. It seems noteworthy that oestrus in these animals, when it did appear, was normal both in the number and type of vaginal cells. The abnor-

malinity, then, is not due to the secretion of an amount of the follicular hormone inadequate to induce full oestrus, since these animals did not show a mixed type of smear.

The animals which had one-third or more of the normal amount of anterior hypophysis showed the regular four- to five-day cycles except in one rat, B 650, in which double this amount of anterior-lobe tissue was present and in which the cycles were slightly longer. An occasional normal animal has unusually long cycles. One animal with but one-fourth the normal amount of hypophysis had normal cycles. It thus seems clear that two-thirds or even more of the anterior lobe can be removed without disturbing the sex cycles.

Matings were attempted on seven of the female partially hypophysectomized rats. In only one of these, W 3359, which had but one-tenth of the normal amount of anterior lobe, was there failure. The other six, which had from 32 to 67 per cent of their anterior hypophyses present, mated and bore normal-sized litters. Two of the five partially hypophysectomized males were each placed twice with oestrous females. They mated each time and litters resulted. They had 45 to 46 per cent of their anterior-lobe tissue. Unfortunately, matings were not attempted in the male which had less than this amount.

Totally hypophysectomized rats give a very different response to handling from normal ones. They feel flaccid, are extremely gentle, and are inactive, giving the very definite impression of a loss of body vigor. The partially hypophysectomized animals, even those with the smaller amounts of anterior hypophysis, definitely gave the response of the unoperated animals and could readily be distinguished from the total ablations. Whether there was a definite difference between those having more than and less than one-third the normal amount of anterior hypophysis, as is the case in the other effects studied, was not determined.

DISCUSSION

The data show clearly that the various deficiencies characteristic of complete hypophysectomy in rats are prevented from developing if but one-third or even slightly less of the normal amount of anterior-hypophyseal tissue is present. The animals upon which this determination was made, it must be kept in mind, were being reared under optimum conditions. The temperature and food were favorable for rearing litters of excellent weight and for rapid growth. They were subjected to no conditions of stress. It is possible that, had they been subjected to unfavorable conditions, the mechanism by which deficiency symptoms were prevented in the absence of two-thirds of the glands would have failed.

Because in the rat one-third of the anterior hypophysis is sufficient to prevent the development of a deficiency, it does not necessarily follow that this would be the case in other mammals, especially in the larger ones. In the rat, figuring from the data of Donaldson, the percentage weight of the whole hypophysis on body weight is roughly, for animals weighing between 100 and 300 grams, 0.0044 to 0.0034 for males and 0.0062 to 0.0072 for females. Deducting from these percentages the minimum, 10 per cent, for the posterior hypophysis, they would be reduced to 0.0041 to 0.0031 for the males and 0.0056 to 0.0065 for the females. In man, Rasmussen ('28) gives the most reliable data on the weight of carefully trimmed anterior lobes. He finds the median weight of this lobe in 111 males whose ages vary from twenty to seventy-six years to be 0.3876 gram. He does not give the weight of these individuals, but, estimating it at a minimum of 75 kilograms, the percentage weight of the anterior lobe on body weight would be 0.00051, or approximately one-tenth as much per unit of body weight as in rats.⁵

In the ox there would appear to be a still lower percentage of anterior hypophysis. The weight of the gland is 0.4 to 0.5 gram in animals of the size usually slaughtered, about

⁵ Rasmussen finds that the weight of the anterior hypophysis in man correlates better with stature than with body weight and does not give figures on the latter.

500 kilos, giving a percentage weight of the hypophysis on body weight of 0.001 or less, or approximately one-fortieth that of the rat. Thus even when two-thirds of the anterior hypophysis is removed in rats there is still considerably more (over three times) present per unit of body weight than normally obtains in man and much higher (some thirteen times) than in the ox. There consequently may not be as large a margin of safety in man and the larger mammals as obtains in rats.

It seems of interest that normal vaginal cell types were present at the occasional oestrous periods in the rats in which there remained too small an amount of the hypophysis to give regular sex cycles. Since the injection of less than unit dosages of oestrin in spayed rats causes a mixed instead of the pure cornified type, it is obvious that at these occasional periods, pituitary fragments stimulated the granulosa sufficiently to secrete at least the minimal amount of sex hormone necessary for oestrus. That there was a deficiency of the follicle-stimulating hormone of the hypophysis, however, is evidenced by the failure of the usual number of follicles to develop. This lowering of the secretory output of the hypophysis did not prevent its periodical release. The situation seems somewhat analogous to that obtaining in monkeys during the summer season. At this time, although menstrual periods occur at regular intervals, visible graafian follicles are lacking and ovulation does not occur (Hartman, '30).

It may be worth while to emphasize a point which seems obvious from this study. The development of disabilities after hypophysectomy should not be relied upon to determine whether a complete ablation of the anterior hypophysis was done until a norm for that particular form has been established. This can only be established when careful anatomical examinations in a series of animals have demonstrated that this lobe was completely removed.

SUMMARY

The effects of partial ablation of the anterior hypophysis on general body growth, the thyroids, adrenals, reproductive organs, and reproduction have been studied in a series of rats. The weights of the fragments of the anterior hypophysis at autopsy varied from 10 to 90 per cent of that of the respective littermate controls.

General body growth, as determined by weight and total length, and the weights of the thyroids, adrenals, and gonads were normal in those animals in which a fragment of the anterior pituitary equal to 30 per cent or more of the weight of this gland in the controls was found at autopsy. When distinctly less amounts were present, there was dwarfing and the above-named glands were below the weight of those of the controls. Ten per cent of the anterior pituitary (about 1 mg.), however, prevented the full development of the disabilities invariably appearing in total ablations.

No structural abnormalities of the thyroid and adrenals were distinguished even in those animals which had the smaller amounts of anterior hypophysis. The ovaries, on the other hand, showed a decrease in the number of follicles and corpora lutea in the more complete ablations, and the sex cycles were irregular. They were normal when 30 per cent of the anterior hypophysis was present, as were also the sex cycles, mating, and reproduction.

The results show that in the rat the anterior hypophysis has a large margin of safety.

LITERATURE CITED

- HARTMAN, C. G. 1930 Reproductive phenomena in the monkey, *Macacus rhesus*. *Am. J. Obst. and Gyn.*, vol. 19, pp. 3-8.
- LOEB, L., AND R. B. BASSETT 1929 Effect of hormones of anterior pituitary on thyroid gland in the guinea-pig. *Proc. Soc. Exp. Biol. and Med.*, vol. 26, pp. 860-862.
- RASMUSSEN, A. T. 1928 The weight of the principal components of the normal male adult human hypophysis cerebri. *Am. J. Anat.*, vol. 42, pp. 1-27.
- SCHOCKAERT, J. A. 1931 Hyperplasia of the thyroid and exophthalmus from the treatment with anterior pituitary in young ducks. *Proc. Soc. Exp. Biol. and Med.*, vol. 29, p. 306.
- 1932 Enlargement and hyperplasia of the thyroids in young ducks from the injection of anterior pituitary. *Am. J. Anat.*, vol. 49, p. 379.

- SMITH, P. E. 1930 Hypophysectomy and a replacement therapy. *Am. J. Anat.*, vol. 45, pp. 205-273.
- 1931 The secretory and regenerative capacity of the anterior hypophysis as evidenced by a study of partial hypophysectomies in rats. *Anat. Rec.*, vol. 48, p. 33.
- 1932 The non-essentiality of the hypophysis in parturition. *Am. J. Physiol.*, vol. 99, pp. 345-348.

PLATE 1

EXPLANATION OF FIGURES

3 The left ovary of rat W 3360, partially hypophysectomized at the age of 304 days and autopsied 274 days later. It had a fragment of the anterior hypophysis 36 per cent of the weight of this gland in its littermate control. $\times 32$.

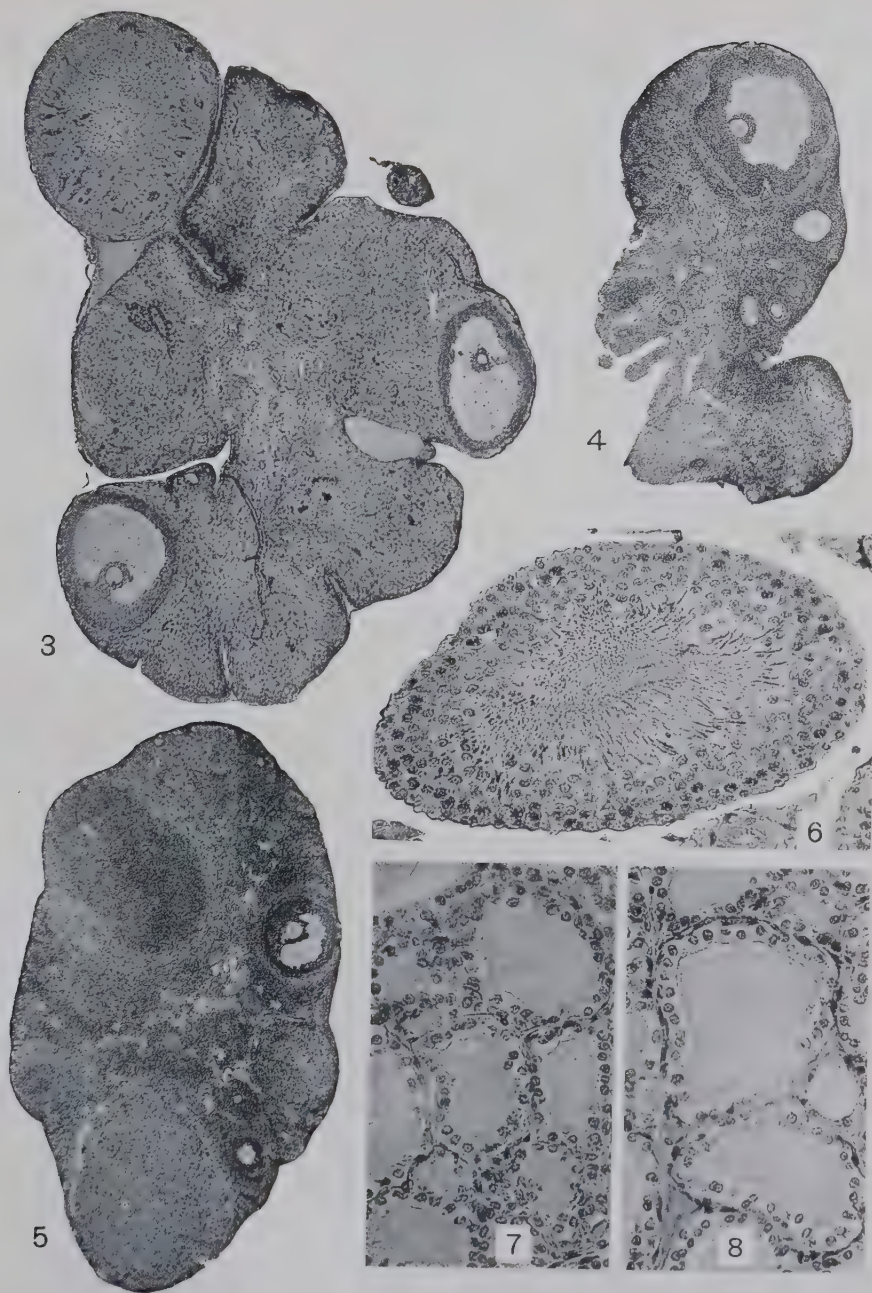
4 The left ovary of rat W 3359, a littermate of the above. A fragment of the anterior hypophysis 10 per cent of the weight of this gland in the control was present. The only large follicle present in this ovary is shown. $\times 32$.

5 The right ovary of GH 2929, operated upon at the age of sixty-four days and autopsied forty-four days later. A fragment of the anterior hypophysis 11 per cent of the weight of this gland in the control was present. The largest follicle in the ovary is shown. $\times 32$.

6 Tubule of the left testis of rat GH 2632, operated upon at the age of ninety-seven days and killed forty-nine days later. A fragment of the anterior hypophysis 31 per cent of the weight of this gland in the control was found. Normal spermatogenesis. $\times 266$.

7 A characteristic region of the left thyroid of rat W 3360. $\times 266$.

8 Left thyroid of rat W 3359.



A QUANTITATIVE STUDY OF ROTATION OF THE KNEE JOINT IN MAN

ROBERT F. ROSS

Department of Anatomy, Dalhousie University, Halifax, Canada

TWO FIGURES

In a study of the knee joint it was observed that the ability to rotate the tibia on the femur during flexion of the joint varied greatly with the individual and with the degree of flexion. A study of several standard texts indicated a lack of agreement about the range of the movements and a paucity of information on the subject in general. A search of the literature failed to discover any recent work on this subject.

In 1853, Meyer published a series of papers on the mechanics of the knee joint. He placed therein a table to show the ability of the foot and calf to rotate at various positions of flexion. His method was to render the ankle immovable by a tight bandage and to record the motion by binding a ruler to the sole of the foot. The angles measured were the angles between lines drawn parallel to this ruler on a sheet of paper under the sole. Full extension being taken as a position of 180° , his results were as follows:

<i>Position of knee</i>	<i>Amount of rotation</i>
150°	32°
120°	33°
90°	42°
60°	52°

He did not record the number of cases examined. The figures were taken to indicate that, as flexion increased, the ability of the tibia to rotate increased.

Other authorities in recent years have given various statements. Quain ('15) claims that at 90° of flexion the total

rotation is about 50° and increases with further bending. Cunningham regards rotation as freest when the knee is flexed to about a right angle. Gray's statement is that the rotation is the freest when the leg is bent at right angles with the thigh. Piersol indicates that rotation is slight at less than semiflexion, regarding the position of freest rotation as uncertain. Fick ('29) reviewed the mechanics of the knee without reference to this aspect. Various clinical writers, such as Ashhurst ('26), Clark ('21, '22), and Robinson ('21),

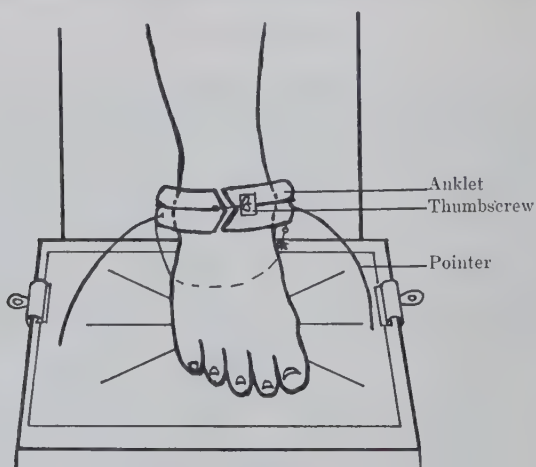


Fig. 1 Drawing of plaster anklet in position.

have discussed the problem from the point of view of measurement of the mobility of the joints after injury or disease (of the joint).

METHODS

A heavy plaster cast was made of an average right ankle, fitting exactly over the two malleoli and into the depressions anterior and posterior to them. This was then removed and trimmed into medial and lateral halves which formed a tight anklet (fig. 1). A metal band, which could be tightened with a thumbscrew, was fitted into the groove on the outside. By means of the thumbscrew the anklet could be made so tight

that slipping was impossible. Stiff metal pointers were inserted into each half of the ankle. The subject sat on the table with the condyles of the femur held fixed by wedges on each side. The positions of the pointers were marked on a paper clipped to a platform which was perpendicular to the long axis of the leg. By joining the points, lines were produced from which the angles of medial and lateral rotation could be determined. The angle was not measured until afterward and only to the nearest degree. The right knee was always tested, because the right ankle only would fit the apparatus. All rotations of the leg were passive, the subject being told to relax his muscles, and all measurements were completely taken by the author. Rotation of the tibia and fibula was caused by torsion exerted on the calf without disturbing the ankle. The calf was caused to turn until a definite point of resistance appeared to have been reached, beyond which a greatly increased force was necessary to cause rotation. One hundred students were selected entirely at random and measured, and one set of twenty-five measurements were taken on one person. Measurements were taken with the knee flexed in three positions, the angle at the knee being 135° , 90° , and 45° for the three positions, respectively. The apparatus was set so that these angles were the same from the first to the last of the series.

In taking the measurements of medial and lateral rotation the knee was allowed to assume a position of rest. This position was recorded and then the measurement taken by turning medially or laterally from that, and the angle formed was called the medial or lateral rotation, respectively. In this case the longitudinal axis of the foot did not necessarily have to point directly forward in the neutral position—which was the criterion used by Meyer.

Before presenting the results of this study, the writer wishes to acknowledge his indebtedness to Prof. Donald Mainland for suggesting the problem and for generous assistance throughout the course of the work.

RESULTS

a. Investigations on one individual

The series of twenty-five measurements taken upon one person formed a test of the method. The measurements were taken at intervals of from one day to several weeks over a period of five months. The person selected was one who might be expected to show as great a variation as possible, a youth who was nineteen years of age, still growing, and very active in his work and sport.

The results of the twenty-five measurements were as follows:

	<i>Degrees</i>	<i>Degrees</i>	<i>Degrees</i>
Flexion of knee,	135	90	45
Mean rotation medially,	15.40	14.92	14.96
Mean rotation laterally,	18.96	16.96	16.80
Mean total rotation,	34.36	31.88	31.76

Statistical quantities calculated from total rotations only:

Flexion of knee,	135°	90°	45°
Standard deviation of series,	±4.52	±3.77	±3.80
Standard error of mean,	±0.904	±0.754	±0.760
Coefficient of variation of series,	13.2%	11.8%	11.9%
Standard error of coefficient of variation,	±1.896	±1.690	±1.692

Since the difference between the two means, to be significant, must be at least twice its standard error, it is obvious that there is no difference between the total amount of rotation at 90° and that at 45°. There is, however, a definite increase over each of them found in the rotation at 135° of flexion.

It is clear that there is no significant difference between the coefficients of variation at the different positions. These coefficients (between 11 and 14 per cent) should be compared with the coefficients found from measuring the hundred students (below).

b. Investigations on one hundred individuals

Table 1 shows the data obtained from the one hundred male university students.

TABLE 1

Rotation of knee in one hundred male students, with associated data

SERIAL NUMBER	AGE IN YEARS	WEIGHT IN POUNDS	HEIGHT IN INCHES	ATHLETICS	RACE	ROTATION AT 90° OF FLEXION IN DEGREES			ROTATION AT 135° OF FLEXION IN DEGREES			ROTATION AT 45° OF FLEXION IN DEGREES		
						Med.	Lat.	Total	Med.	Lat.	Total	Med.	Lat.	Total
1	22	110	67	0	Eng.	12	17	29	25	23	48	12	16	28
2	25	156	69	0	Scot.	26	21	47	21	27	48	26	25	51
3	22	125	66	0	Eng.	27	13	40	20	23	43	25	18	43
4	25	140	68	M	Eng.	24	27	51	39	30	69	23	21	44
5	22	150	68	0	Eng.	16	22	38	20	26	46	22	19	41
6	21	151	69	L	Scot.	17	18	35	22	22	44	14	22	36
7	22	148	70	L	Eng.	26	16	42	22	21	43	23	15	38
8	23	160	71	L	Eng.	22	16	38	19	21	40	23	17	40
9	20	133	70	M	Scot.	22	15	37	23	22	45	22	15	37
10	24	135	68	M	Eng.	18	20	38	11	21	32	20	18	38
11	21	165	70	L	Eng.	18	17	35	17	24	41	19	27	46
12	22	175	72	H	Scot.	14	18	32	17	21	38	19	20	39
13	23	137	70	0	Fr.	20	23	43	13	18	31	16	15	31
14	22	147	67	L	Eng.	19	22	41	16	21	37	30	23	53
15	22	155	71	0	Eng.	23	26	49	21	26	47	21	21	42
16	29	154	70	0	Ir.	22	23	45	20	26	46	23	14	37
17	23	151	68	L	Scot.	19	26	45	17	27	44	21	22	43
18	21	176	73	H	Scot.	18	15	33	10	24	34	12	17	29
19	22	170	68	H	Eng.	25	21	46	24	23	47	19	21	40
20	20	150	67	L	Scot.	19	25	44	13	23	36	19	20	39
21	21	132	68	L	Neg.	15	17	32	18	17	35	17	22	39
22	25	142	68	L	Hind.	9	22	31	14	25	39	22	12	34
23	23	170	69	H	Scot.	21	22	43	15	32	47	30	20	50
24	22	170	71	L	Eng.	19	21	40	23	26	49	26	22	48
25	21	155	69	M	Hebr.	15	14	29	15	25	40	12	16	28
26	21	150	68	M	Hebr.	16	22	38	19	15	34	15	11	26
27	25	160	69	M	Eng.	15	15	30	16	12	28	22	23	45
28	23	170	69	H	Scot.	22	27	49	23	27	50	15	19	34
29	23	150	70	0	Eng.	15	22	37	9	22	31	17	14	31
30	23	135	67	0	Hebr.	18	19	37	30	12	42	22	21	43
31	21	165	72	0	Eng.	16	24	40	16	21	37	17	18	35
32	25	165	70	L	Scot.	10	19	29	15	16	31	14	18	32
33	20	145	69	L	Ir.	23	24	47	24	17	41	16	21	37
34	22	130	69	L	Eng.	20	18	38	18	27	45	20	31	51
35	25	145	68	M	Scot.	21	21	42	19	23	42	17	21	38
36	19	150	71	L	Eng.	15	21	36	32	23	55	20	20	40
37	21	118	66	0	Scot.	12	32	44	34	23	57	15	29	44
38	20	150	69	M	Scot.	15	24	39	19	29	48	17	22	39
39	22	168	71	L	Scot.	10	25	35	14	25	39	18	26	44
40	29	148	66	0	Port.	21	19	40	16	18	34	21	17	38
41	21	157	68	H	Hebr.	17	13	30	14	17	31	16	14	30
42	25	148	69	L	Ir.	26	15	41	26	21	47	31	17	48
43	22	157	73	H	Scot.	22	21	43	21	23	44	24	26	50
44	20	142	69	L	Ir.	18	16	34	16	18	34	31	19	50
45	19	145	69	H	Eng.	17	28	45	23	24	47	37	21	58
46	18	128	68	H	Eng.	26	23	49	20	25	45	25	30	55
47	20	125	67	L	Hebr.	19	21	40	31	21	52	23	17	40
48	28	185	72	L	Scot.	13	14	27	12	20	32	13	15	28
49	21	123	71	L	Scot.	16	11	27	23	16	39	18	11	29
50	22	156	71	L	Eng.	19	20	39	15	33	48	21	18	39

TABLE 1—Continued

SERIAL NUMBER	AGE IN YEARS	WEIGHT IN POUNDS	HEIGHT IN INCHES	ATHLETICS	RACE	ROTATION AT 90° OF FLEXION IN DEGREES			ROTATION AT 135° OF FLEXION IN DEGREES			ROTATION AT 45° OF FLEXION IN DEGREES		
						Med.	Lat.	Total	Med.	Lat.	Total	Med.	Lat.	Total
51	19	118	65	L	Hebr.	9	17	26	16	20	36	14	16	30
52	20	152	71	L	Fr.	18	27	45	15	24	39	32	17	49
53	20	133	69	L	Scot.	13	18	31	11	25	36	16	14	30
54	23	165	69	L	Port.	20	18	38	10	20	30	16	17	33
55	21	140	66	L	Scot.	14	14	28	18	27	45	13	14	27
56	20	152	68	L	Eng.	18	10	28	22	16	38	18	13	31
57	23	128	67	L	Eng.	17	21	38	13	15	28	20	10	30
58	21	160	68	L	Eng.	15	17	32	25	16	41	29	11	40
59	17	120	65	L	Scot.	17	13	30	23	19	42	20	13	33
60	21	145	66	L	Dut.	13	15	28	19	20	39	18	13	31
61	24	125	63	L	Ir.	19	19	38	13	21	34	25	13	38
62	22	150	69	L	Hebr.	11	13	24	23	24	47	19	12	31
63	25	134	67	L	Scot.	18	11	29	16	21	37	32	11	43
64	24	145	64	L	Hebr.	20	9	29	24	16	40	32	12	44
65	28	150	70	L	Scot.	20	12	32	10	27	37	20	19	39
66	26	152	68	H	Scot.	20	14	34	21	20	41	18	24	42
67	22	165	71	L	Hebr.	19	22	41	16	31	47	19	24	43
68	18	139	68	H	Eng.	21	23	44	29	9	38	24	15	39
69	21	150	69	M	Eng.	20	20	40	22	24	46	21	21	42
70	20	164	69	H	Eng.	15	15	30	27	18	45	22	14	36
71	24	200	74	H	Ir.	10	20	30	24	18	42	20	18	38
72	19	132	68	L	Eng.	13	18	31	22	18	40	29	16	45
73	20	155	69	H	Eng.	12	14	26	11	18	29	24	11	35
74	18	140	68	L	Scot.	23	17	40	25	29	54	25	30	55
75	22	155	72	H	Scot.	22	19	41	14	32	46	26	18	44
76	21	140	67	L	Scot.	16	27	43	8	36	44	23	27	50
77	20	156	70	L	Scot.	27	23	50	17	26	43	23	29	52
78	22	138	68	M	Scot.	17	17	34	14	19	33	18	12	30
79	30	165	71	L	Eng.	28	14	42	19	31	50	25	28	53
80	20	157	67	M	Fr.	18	26	44	22	21	43	26	16	42
81	21	153	71	L	Eng.	26	15	41	18	24	42	19	15	34
82	23	165	72	L	Ir.	27	21	48	11	23	34	24	18	42
83	27	145	68	0	Eng.	10	15	25	24	23	47	24	16	40
84	22	135	69	L	Scot.	11	19	30	10	21	31	20	15	35
85	22	165	72	L	Eng.	11	24	35	22	23	45	27	16	43
86	26	195	72	H	Scot.	16	19	35	11	25	36	14	19	33
87	24	129	67	M	Eng.	11	25	36	24	22	46	22	14	36
88	30	130	67	0	Neg.	22	10	32	15	26	41	20	21	41
89	21	150	65	L	Hebr.	13	13	26	18	19	37	18	16	34
90	22	118	68	L	Eng.	18	19	37	20	25	45	34	12	46
91	21	172	72	M	Hebr.	15	12	27	14	23	37	10	25	35
92	22	168	69	L	Eng.	13	13	26	6	18	24	10	20	30
93	19	182	73	L	Eng.	14	19	33	19	23	42	14	20	34
94	25	182	76	H	Scot.	22	12	34	18	12	30	17	10	27
95	26	172	74	M	Scot.	18	21	39	15	18	33	26	19	45
96	22	124	66	L	Scot.	18	16	34	23	23	46	27	19	46
97	27	172	66	L	Hebr.	12	14	26	17	12	29	16	18	34
98	21	193	68	M	Hebr.	10	14	24	9	19	28	18	15	33
99	21	140	66	M	Scot.	26	16	42	26	17	43	27	23	50
100	21	126	67	L	Ir.	20	21	41	15	21	36	18	16	34

H = Heavy exercise. M = Moderately heavy exercise. L = Light exercise. 0 = Very little or no exercise. Scot. = Scotch. Eng. = English. Hebr. = Hebrew. Ir. = Irish. Neg. = Negro. Hind. = Hindu. Port. = Portuguese. Fr. = French. Dut. = Dutch.

Statistical quantities calculated from table 1

	MEAN ROTATION, DEGREES	STANDARD DEVIATION, SERIES	STANDARD ERROR MEAN	COEFFICIENT OF VARIATION, PER CENT	STANDARD ERROR OF COEFFICIENT OF VARIATION
Knee flexed to 90°					
Total rotation	36.56	±6.79	±0.679	18.6	±1.36
Medial rotation	17.84	±4.71	±0.471	26.5	±2.00
Lateral rotation	18.72	±4.69	±0.469	25.5	±1.92
Knee flexed to 135°					
Total rotation	40.64	±7.25	±0.725	17.8	±1.29
Medial rotation	18.64	±5.90	±0.590	31.5	±2.39
Lateral rotation	22.00	±4.84	±0.484	22.0	±1.60
Knee flexed to 45°					
Total rotation	39.25	±7.36	±0.736	18.75	±1.37
Medial rotation	20.93	±5.48	±0.548	26.2	±1.98
Lateral rotation	18.32	±4.89	±0.489	26.7	±2.02

Figure 2 shows the frequency distribution for the three positions.

That the variation found in the hundred individuals is not the result of either variation in the method or in the individual is shown by a comparison of the coefficients of variation.

Flexion of knee,	90°	135°	45°
Coefficient of variation, for 100 individuals (one reading each),	18.6%	17.8%	18.75%
Coefficient of variation, one individual (twenty-five readings),	11.8%	13.2%	11.9 %
Differences between coefficients of variation,	6.8%	4.6%	6.85%
Standard errors of difference,	±2.17	±2.29	±2.17

The differences between the coefficients of variation in the individual case and in the hundred cases are at least twice their standard errors. So we can confidently state that some other factors are responsible and that the method is reliable.

Comparison of total rotations

The most interesting result here is that the mean total rotation is least at the position of 90° of flexion. That the difference is significant is shown by the following comparison:

Difference between mean total rotation at 90° and 135°,	4.08°
Standard error of difference,	± 0.993
and,	
Difference between mean total rotations at 90° and 45°,	2.69°
Standard error of difference,	± 1.00

On comparing the mean total rotation at 135° of flexion with the mean total rotation at 45° of flexion, it is seen that the rotation at 135° is slightly greater, but the difference is

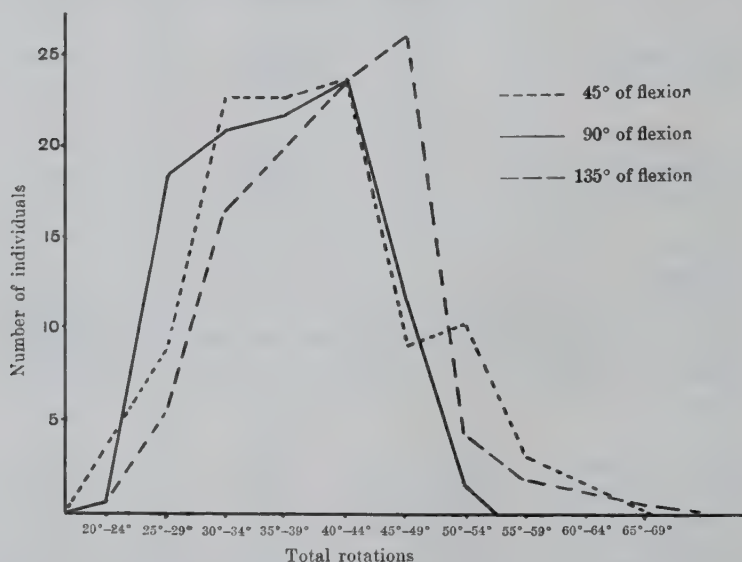


Fig. 2 Frequency distribution of one hundred individuals according to total rotation of knee at three different angles of flexion.

not significant, being only 1.39° with a standard error of ± 1.03 .

Not only is there a lower mean at 90° of flexion than at the other two positions, but an examination of the individuals separately gives the following unexpected results:

Comparison of rotations at 90° and 135° in individuals (one hundred cases)

Number of individuals with less rotation at 90° than at 135° ,	72
Number of individuals with equal rotation at 90° and 135° ,	3
Number of individuals with greater rotation at 90° than at 135° ,	26

Comparison of rotations at 90° and 45° in individuals (one hundred cases)

Number of individuals with less rotation at 90° than at 45°,	61
Number of individuals with equal rotation at 90° and 45°,	9
Number of individuals with greater rotation at 90° than at 45°,	30

Comparison of rotations at 45° and 135° in individuals (one hundred cases)

Number of individuals with less rotation at 45° than at 135°,	52
Number of individuals with equal rotation at 45° and 135°,	6
Number of individuals with greater rotation at 45° than at 135°,	42

Therefore it is seen that in a large proportion of these individuals rotation at 90° was exceeded by rotation in one or other of the other positions, although a certain definite minority do not exhibit this property of the joint.

In some cases where rotation at 135° exceeds rotation at 90° the rotation at 90° will in turn exceed that at 45°. Any one of the three positions may exhibit the lowest rotation or the highest rotation. In view of the fact that many books make the statement that rotation is greatest at semiflexion, a count was made of the individuals, in order to determine the number that had the freest rotation of the three positions at 90° and the number that had the least rotation of all at this position, in one hundred individuals.

Individuals with greatest (freest) rotation at 90° of flexion (semiflexion),	17
Individuals with the least rotation at 90° of flexion (semiflexion),	53

These results would indicate that whether the statements found in text-books refer to the average rotation or to the condition found in the majority of individuals, they disagree with the results of this work.

Correlation of rotations at different degrees of flexion

As would be expected, there was a tendency for a joint which rotated freely in one position to rotate freely in others, and vice versa. This was verified by the preparation of correlation surfaces. One of these, showing the correlation between the rotation at 90° of flexion and 45° of flexion, is shown (table 2). The others were similar in form.

Coefficient of correlation between mean total rotations at 90° of flexion and 45° of flexion, + 0.62 (standard error, ± 0.063).

Coefficient of correlation between mean total rotations at 90° of flexion and 135° of flexion, + 0.43 (standard error, ± 0.071).

Coefficient of correlation between mean total rotations at 135° of flexion and 45° of flexion, + 0.54 (standard error, ± 0.080).

TABLE 2
Correlation between rotations at 90° and at 45°

DEGREES		TOTAL ROTATION AT 90° OF FLEXION							
		20-24	25-29	30-34	35-39	40-44	45-49	50-54	Total
Rotation at 45° flexion	55-59					1	2		3
	50-54			1	1	6	1	1	10
	45-49			3	3	2	1		9
	40-44		3	3	6	7	4	1	24
	35-39		2	6	7	6	2		23
	30-34	2	7	6	4	3	1		23
	25-29		5	2	1				8
	20-24								
Total		2	17	21	22	25	11	2	100

Comparison between medial and lateral rotation

At the 90° position it is evident that lateral and medial rotation do not differ materially.

Difference between lateral and medial rotation, 0.88°
Standard error of difference, ± 0.665

At the 135° position:

Difference between lateral and medial rotation, 3.36°
Standard error of difference, ± 0.763

This indicates that the mean lateral rotation is significantly greater.

At the 45° position:

Difference between lateral and medial rotation, 2.61°
Standard error of difference, ± 0.734

This indicates that the mean lateral rotation is significantly less.

Referring to the individual cases, we find the following:

At 90° of flexion

Number of cases where medial rotation exceeds lateral,	36
Number of cases where medial rotation equals lateral,	9
Number of cases where lateral rotation exceeds medial,	55

At 135° of flexion

Number of cases where medial rotation exceeds lateral,	34
Number of cases where medial rotation equals lateral,	2
Number of cases where lateral rotation exceeds medial,	64

At 45° of flexion

Number of cases where medial rotation exceeds lateral,	60
Number of cases where medial rotation equals lateral,	3
Number of cases where lateral rotation exceeds medial,	37

Summing up, we might state that as the knee is flexed from 135° to 45° the excess of the lateral rotation over the medial diminishes until at 90° they are practically equal, and the process continues until at 45° the medial rotation is significantly greater than the lateral.

Although this is true in the average case and is true in the majority of individuals, there is a substantial minority of cases which do not follow this rule.

EFFECT OF EXERCISE

As each measurement was taken, information was obtained regarding the athletic practices of each subject, a classification being made, according to the effort demanded: 1) heavy (football, etc.); 2) medium (tennis, basketball, etc.); 3) light (walking, hiking, etc.), and, 4) very little or no exercise. These are shown on table 1 as: heavy, H; medium, M; light, L, and very little or none as 0.

Classes 1 and 2 were taken as one group and the remainder, who indulged in little or no sport, were taken as the other.

The comparison was as follows:

Angle of flexion	90°	135°	45°	NUMBER IN GROUP
Mean total rotation in athletic group	36.46°	39.35°	38.23°	34
Mean total rotation in non-athletic group	36.60°	41.30°	39.66°	66
Difference	0.14°	1.95°	1.43°	

The differences here are within the margins of error, so there is no appreciable difference in the mobility of the joints due to strenuous athletic endeavor.

EFFECT OF AGE

The subjects measured ranged in age from seventeen to thirty-one years. The coefficient of correlation between age and total rotation at 90° of flexion was + 0.13, with a standard error of ± 0.093 .

EFFECT OF HEIGHT

The heights of the one hundred subjects ranged from 63 inches to 76 inches, with an average height of 68.9 inches. The coefficient of the correlation between height and rotation at 90° of flexion was + 0.111, with a standard error of ± 0.098 .

EFFECT OF WEIGHT

The weights of the subjects ranged from 112 to 202 pounds, with an average weight of 151 pounds. The coefficient of the correlation between weight and rotation at 90° of flexion was - 0.044, with a standard error of ± 0.099 .

EFFECT OF RACE

The racial origin of the subjects was mainly English, Scottish, Hebrew, and Irish. Racial distribution was as follows:

RACE	NUMBER	MEAN ROTATION AT 90° OF FLEXION
		<i>Degrees</i>
English	36	37.47
Scottish	34	36.99
Hebrew	13	30.54
Irish	8	40.40
French	3	44.00
Negro	2	32.00
Portuguese	2	39.00
Hindu	1	31.00
Dutch	1	28.00

Comparison of Hebrews with remainder

RACE	MEAN TOTAL ROTATION	STANDARD ERROR
90° of flexion		
Hebrews (13)	30.54	± 1.652
Non-Hebrews (87)	37.40	± 0.694
135° of flexion		
Hebrews	38.46	± 1.932
Non-Hebrews	40.97	± 0.775
45° of flexion		
Hebrews	34.69	± 1.603
Non-Hebrews	39.93	± 0.780

It is seen from the above that there is a marked difference between the Hebrews and the remainder at 90° and at 45°. But at 135° there was no significant difference. Since the number of Hebrews was small, it was necessary to apply a more strict test than the standard-error test to insure that the difference might not be due to chance. Fisher's ('30) *t* test indicated that the difference between the mean rotations for the Hebrews and that for the rest at 90° of flexion was highly significant ($t = 3.57$, $n = 98$, $P = < .01$). Similarly, the difference at 45° of flexion was significant ($t = 2.44$, $n = 98$, $P = < .02$). Therefore the mean rotation at 90° and 45° of flexion was significantly less in the Hebrews than in the non-Hebrews.

SUMMARY

These investigations concern themselves with the ability of the knee to permit rotation at three positions of flexion, namely, quarter-flexion (angle at knee of 135°), semiflexion (angle at knee of 90°), and three-quarter flexion (angle at the knee of 45°).

A summary of the work done previously on this subject is given with examples of some of the points upon which anatomists fail to agree.

Apparatus which was developed is described and the methods used, with precautions, are given.

Twenty-five measurements were taken on one individual and one hundred single sets of measurements were taken on one hundred individuals. All subjects were male university students.

Results obtained were as follows:

Measurements on a single individual exhibited some variation, but significantly less than that in the general run of others.

The mean total rotations obtained in the hundred students were as follows: at quarter-flexion, 40.64° ; at semiflexion, 36.56° ; and at three-quarter flexion, 39.25° .

A count of the individuals showed a large proportion (fifty-three out of one hundred) with the least rotation at a position of semiflexion, and that the smallest group (seventeen out of one hundred) had the freest rotation at semiflexion.

Measurements of medial and lateral rotation indicated a tendency for ability of medial rotation to increase as the knee was flexed, and for ability of lateral rotation to decrease.

There was a definite positive correlation between the ability to rotate at one position and the ability to rotate at the other two.

It was shown that the effects of exercise, age, weight, and height were not appreciable on the amount of rotation at semiflexion.

It was shown that a distinct racial group, the Hebrews, differed significantly in their ability to rotate the joint from a mixed group of non-Hebrews, the Hebrews having considerably less motility at 45° and at 135° of flexion.

This work is preliminary to much statistical work that might be done on the movements of the joints. A comparison of the rotations of the right and left knees should be made. The effect of sex, of extremes of age, of racial differences, and of passive movements are some of the aspects which remain to be investigated. With the accumulation of such data a new basis will be formed for the study of the mechanics of the knee joint and other joints.

The method developed has an obvious application in anthropological investigations and in the study of the effects of injury upon the mobility of the knee joint.

LITERATURE CITED

- ASHHURST, A. P. C. 1926 The motions of the larger joints. *Internat. Clin.*, ser. 36, vol. 1, p. 89.
- CLARK, W. A. 1920 A system of joint measurement. *J. Orthop. Surg.*, vol. 2, pp. 687-700.
- 1921 A protractor for measuring the rotation of joints. *J. Orthop. Surg.*, vol. 3, p. 154.
- CUNNINGHAM, D. J. 1930 Text-book of anatomy, 6th ed. New York.
- FICK, R. 1929 Review of literature on mechanics of joints. *Zeitschr. f. ortho. Chir.*, Bd. 51, S. 320-337.
- GRAY, H. 1930 Anatomy, 22nd ed. Philadelphia.
- MEYER, H. 1853 Die Mechanik des Kneigelenks. *Arch. Anat. Physiol. wiss. Med.*
- PIERSOL, G. A. 1930 Human anatomy, 11th ed. Philadelphia.
- QUAIN 1915 Elements of anatomy, 11th ed., vol. 4. London.
- ROBINSON, W. H. 1921 Joint range. *J. Orthop. Surg.*, vol. 3, pp. 41-51.

CELL CHANGES IN THE ANTERIOR LOBE OF THE PITUITARY FOLLOWING CANCER TRANSPLANTATION IN RATS¹

M. F. GUYER AND PEARL E. CLAUS

Department of Zoölogy, University of Wisconsin

TWO PLATES (EIGHTEEN FIGURES)

That characteristic histological changes in the structure of the anterior lobe (pars anterior) of the pituitary body result from castration has long been known. In the case of the albino rat, following Hatai's ('13, '15) interesting observations on the differential increase in weight in the hypophyses of males and females after gonadectomy, Addison ('17) made a careful histological study of the normal male hypophysis, and of the changes consequent upon removal of the testes. He uses the terminology *basophiles*, *acidophiles* (*oxyphiles*), and *reserve cells* for the cellular constituent of the anterior lobe. Among other things Addison found that, following castration in the male albino rat, the basophile cells of the anterior lobe of the pituitary increased in size and number. At two months after the operation the largest basophiles began to show vacuolization and during succeeding months the number of vacuolated cells increased. The oxyphiles were not much affected at first except for a slight diminution in average diameter. Later some of them showed fewer granules and lessened capacity for stain. The number of distinctively stained oxyphiles was clearly reduced at seven months. During the early months following castration some of the reserve cells appeared to become basophile cells, and in later months some of the oxyphiles appeared to dedifferentiate gradually

¹These investigations were supported by a research grant from Mary E. Brittingham.

into reserve cells. Following certain techniques the basophiles displayed a large cytoplasmic body or *macula*, which Addison suggests may be the Golgi apparatus, or the centrosphere, or both combined, while the oxyphiles showed a similar structure, though of much smaller size.

Inasmuch as our preparations of pituitary anterior lobe of both castrated male and female albino rats (figs. 5, 6) show no essential differences in histological behavior from that reported by Addison, they are not described here except in comparison with the corresponding pars anterior of rats into which cancer tissue had been transplanted.

The animals experimented upon were albino rats from the Sprague-Dawley colony which was the source of the stock used earlier in the cathode-ray experiments by Guyer and Daniels ('28). Young animals weighing between 60 and 80 grams were usually selected to receive the transplants. The tumor used was a transplantable form of cancer known as the 'Flexner-Jobling carcinoma' obtained from the Crocker Institute in the spring of 1926 and kept in our laboratory through transplantation from animal to animal. A small bit of cancer tissue taken from the actively growing zone of a carcinoma, which is not too advanced, usually grows rapidly when placed beneath the skin of the belly of a young rat. In from ten to fifteen days it is perceptible as a small tumor. Such tumors vary considerably in their rate of growth in different animals. Within a few weeks they commonly reach a diameter of from 2.5 to 5 cm., and then break down, forming an open ulcerating sore (fig. 1). This breaking down, however, may occur when the tumor is no more than 1 cm. in diameter or it may never take place. Once the transplants have become established, the cancer usually persists and eventually causes the death of the animal. However, there is always an appreciable number of so-called spontaneous cures. For example, in the earlier study alluded to (Guyer and Daniels, '28), out of 312 individuals in which the transplanted tumor had become well established, twenty-four, or about 8 per cent, recovered, with complete disappearance of the

growth. The percentage of transplants which grow and develop is high in our stock of rats, although the physiological condition of the transplanted tissue is an important factor. In our earlier study ('28), of 1114 rats into which transplants were made, 993 developed tumors and 121 did not; or in other words, there were nearly 90 per cent of 'takes.' In a later study, of 446 rats to which transplants have been made, 384, or 82.3 per cent, have developed tumors. In a very recent series which included none of the descendants of cured animals or of animals which had previously proved to be immune, of the fifty males and fifty-two females receiving transplants, all of the males (100 per cent) developed tumors, as did forty-one (nearly 80 per cent of the females).

The present study is concerned with the histological and cytological changes which occur in the anterior lobe of the pituitary coincidently with the development of transplanted carcinoma in albino rats, together with the physiological effects of such anterior-lobe substance when implanted in immature normal rats and mice. In every case the anterior lobe from a normal animal of the same size and often from the same litter was taken as a control.

For general histological purposes the best results were obtained with Bouin's fluid followed by a modified Mallory's triple stain in which a 10 per cent acid fuchsin in anilin water was substituted for the usual weaker acid-fuchsin solution. For study of the Golgi body Ludford's modification of the Mann-Kopsch method (Guyer: *Animal Micrology*, p. 149) was employed. Some sections were cut 4μ ; others, 7μ , thick.

The most outstanding fact which has come to light from the study is that much the same progressive histological and physiological change occurs in the anterior lobe of the pituitary in cancerous individuals as that which follows castration of either males or females.

As is well known, the rat's pituitary consists of four parts: 1) the pars anterior, or anterior lobe; 2) the pars intermedia; 3) the pars tuberalis; and, 4) the pars nervosa, or posterior lobe. Of these, the ventral glandular portion or anterior lobe

is the only part described here, since it was in it that the changes in question were observed.

In figures 2 and 7 the normal condition seen in the young mature or nearly mature animal is pictured. The three characteristic types of cells are observable. The basophiles are the larger cells with the cytoplasm colored moderately with the basic dye. The oxyphiles are the more plentiful, somewhat smaller cells with denser-looking cytoplasm, containing numerous small granules which stain with acid fuchsin. The so-called reserve cells, the supposed unchanged descendants of the embryonal type, are rather inconspicuous cells toward the interior of the numerous cell masses around which the blood vessels form sinusoidal networks. They are more numerous in immature than in mature animals and apparently vary with the functional activity of the part. The relative numbers of the three types of cells vary somewhat in different regions of the anterior lobe—a fact we have borne in mind in all comparative studies. While in general the basophiles and the oxyphiles abut upon the endothelia of the blood vessels, they are occasionally also seen in the midst of groups of reserve cells, but it may be that such glandular cells are in contact with blood vessels above or below the plane of section. It is often difficult to discriminate accurately between the oxyphile and the reserve cells, although on the whole the latter have indistinct borders and are likely to remain largely unstained. In castrated or in cancer-implanted rats, as time goes on, with increase in number there is also more or less increase in the size of the basophile cells and eventually many of them become vacuolated.

Within six or seven weeks after successful cancer transplants have been made, an increase in the number of basophiles is discernible. As the cancer grows this number increases. In animals with well-developed crater-like tumors, the basophiles make up the greater proportion of the anterior-lobe tissue and some of them contain vacuoles (figs. 3 and 4), as described by Addison ('17) for castrated rats. Since no cell division is in evidence in any of the sections, one must

conclude that the new basophiles are arising through the transformation of some other type of cell. It seems not improbable, as maintained by Addison ('17), that this source is the reserve cells, since these gradually become fewer and all intergrades, both in size and staining reactions, between them and the typical basophiles are in evidence. A comparison of figure 2 with figure 4 shows the differences in cell types between the normal rat and one with actively growing cancer. The increase in the number and the size of the basophiles as well as their enhanced stainability are evident. From the fact that the basophiles in the cancerous individuals range from a relatively large size down to that of the reserve cells it is inferred that the smaller basophiles are recently transformed reserve cells. Figure 4 shows a section from a rat with advanced cancer. Not only are the basophiles plentiful, but some of them contain vacuoles which in section may give them a ring-like appearance. They have the look of being gorged with some liquid-like secretion ready for discharge. That they never reach the degree of extreme vacuolization seen in the advanced castrate (fig. 6) of, say, nine months, is doubtless due to the fact that they die of the cancer long before this extreme condition arises. The oxyphiles, although relatively fewer in number, seem little if at all changed. It may be, as Addison suggests for the seven months' castrate, that some of the oxyphiles have become dedifferentiated into reserve cells. When figure 3 is compared with that of the anterior lobe of a thirty-day castrate (fig. 5), the similarity in histological structure is at once apparent.

A conspicuous Golgi-like body, found also in the castrated rat, is characteristic of the basophiles of cancerous rats. Because of the various bits of evidence of the relation of the Golgi body to secretory processes, it is perhaps well here to describe more in detail the close association between this osmiophilic network in the basophiles of the anterior lobe and the vacuoles which appear in castrated or in cancerous rats. When the usual techniques for Golgi apparatus are employed, this coarse network-like structure (figs. 13 to 18) is

in evidence in all basophiles from the smallest to the largest. Occasionally it seems to consist of more or less independent thread-like constituents, but commonly it appears as a continuous basket-like meshwork. In the smaller basophiles it commonly takes the form of a small semilunar mass with its concavity capped around one edge of the nucleus. It increases in size with the size of the basophiles. In the non-vacuolated ones it has typically a spherical or oval outline (figs. 13 to 15), but with the appearance of the vacuole, with which it is always in contact, it becomes indented on the vacuolar side (fig. 16). As the vacuole enlarges this concavity comes more and more into prominence (fig. 17) until in the case of the larger vacuoles, the body lies as a crescentic rim along one edge of the vacuole (fig. 18). In this stage it may seem more granular than fibrous and it is also of smaller size than at the beginning of vacuolization. The whole sequence of appearances indicates formation of the vacuole at the expense of the Golgi body either by direct transformation or by its employment as a localized center for the transformation of other cell constituents into the vacuolar material.

A similar prominence of the Golgi apparatus in the other type of secretory cell found in the anterior lobe, the oxyphiles, occurs (fig. 12). In view of the confused and sometimes conflicting evidence regarding the nature of the Golgi apparatus, due to its presence in such presumably non-secretory cells as nerve cells, muscle cells, and sperm cells, we have no suggestions to offer regarding its general significance. All we can affirm is that in the material under consideration it seems to play an important part in the formation of the vacuolar material of the basophile cells of castrate or of cancerous rats. While the Golgi complex is often located in the cell between the nucleus and the blood vessel into which any hormone secreted by the cell would be discharged, in our preparations there are so many exceptions to this that we cannot say it is the rule; the arrangement, indeed, seems to be more or less arbitrary.

One fairly consistent difference between the enlarged basophiles of castrates and those of cancerous individuals, however, is to be seen in the greater frequency with which the nuclei of the latter become distorted from their earlier typical spheroidal shape. The deformation commonly appears as an indentation on the side of the nucleus turned toward the Golgi apparatus. Whereas in the earlier stages of basophile transformation the Golgi body not infrequently appears as a cap-like structure embracing one surface of the nucleus, in later stages it commonly comes to occupy the center of the cell, the nucleus is crowded to one side and often has the appearance of capping the Golgi area. In the photograph of the anterior-lobe cells shown in figure 4, such indentures of the nucleus are visible, although the technique employed was not one that reveals the Golgi body itself. Figure 14 is a camera-lucida drawing of an anterior-lobe basophile in advanced cancer where this relation of nucleus and Golgi body is more clearly represented. While similar distortions of the nucleus may occur in the basophiles of castrates, in our material, selected from various individuals, it is of much less frequency than in the corresponding cells of cancerous rats.

That there is increased endocrine potency in anterior lobes with vacuolated basophiles can readily be demonstrated by transplanting such lobes to immature mice and rats, and comparing the effects with those produced by similar transplants from normal individuals. Evans and Simpson ('28) found that the potency of the hormone from the pituitary anterior lobe of castrate rats in inducing precocious sexual development was about two and a half times greater than that of corresponding transplants from normal rats. We find, likewise, that when anterior-lobe substance from rats with advanced cancer is used the potency is consistently increased. In young mice such transplants lead to opening of the vaginal orifice at twenty-one to twenty-two days of age together with enlargement of the uterus and, what is more significant, an increase in size of the ovaries together with

the appearance of corpora lutea over the ovarian surface. The data for this conclusion are presented in table 1. Moreover, we found also that the anterior-lobe substance of castrated cancerous rats was more potent than that of castrated normal rats in inducing sexual precocity in mice (table 2).

TABLE 1

IMMATURE MOUSE NO.	WEIGHT OF OVARIES, GRAMS	REMARKS
1	0.0196	Donors: Cancerous rats. Five pituitaries in each mouse
2	0.0207	
3	0.0154	
4	0.0138	
5	0.0143	
1	0.0130	Donors: Non-cancerous rats. Five pituitaries in each mouse
2	0.0076	
3	0.0103	

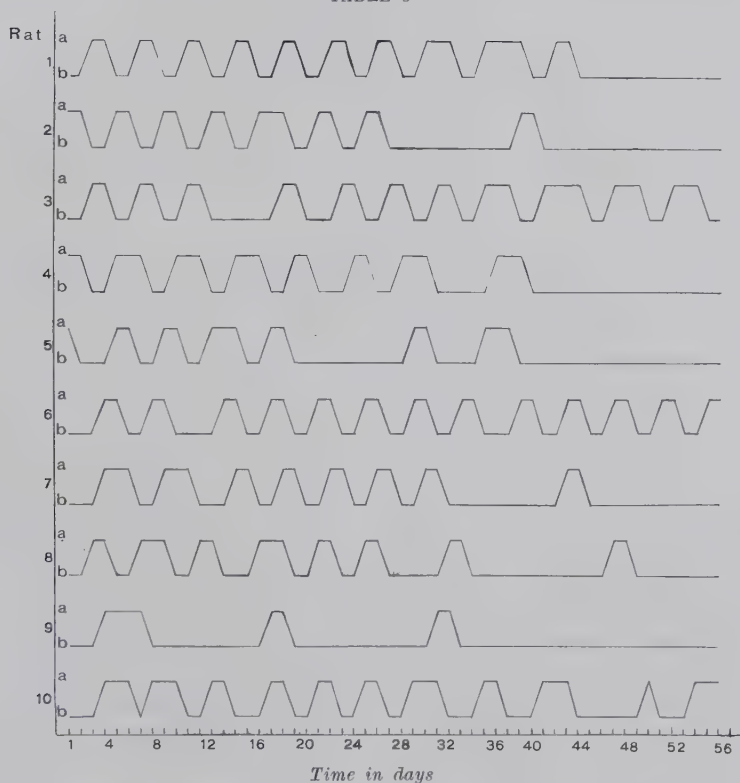
TABLE 2

IMMATURE MOUSE NO.	WEIGHT OF OVARIES, GRAMS	REMARKS
1	0.0213	Donors: Cancerous cas- trate rats. Two pitui- taries in each mouse
2	0.0205	
3	0.0188	
4	0.0220	
5	0.0188	
6	0.0180	
7	0.0231	
1	0.0120	Donors: Non-cancerous castrate rats. Two pi- tuitaries in each mouse
2	0.0117	
3	0.0154	

Recognition of the striking similarity between the effects of castration and those of cancer upon the histological structure and physiological output of the anterior lobe of the pituitary body inclines one at first thought to conclude that the changes are probably referable to the same initial cause, namely, interference with the normal ovarian follicular secretions. To the authors this at one time seemed all the more probable because of their discovery (paper in press) that certain sterilizing emulsions they were using on female rats produced a somewhat similar histological picture in the

hypophysis to that which follows castration, and that coincidentally the growing follicles in the ovaries became atretic and did not mature their ova. However, the matter is not so simple in the case of cancerous rats. No follicular atresia

TABLE 3



a = Estrum. b = Diestrus.

is in evidence in rats with even advanced cancers. Moreover, individuals in all stages of cancer growth will mate and bear young, and furthermore, cancerous rats in which the estrual rhythm has been followed day after day by means of smears (table 3, which shows the estrual cycles of ten rats with advanced cancer) ordinarily show little or no irregularity in

the cycle up until they are practically moribund. Lastly, the fact that anterior-lobe substance of cancerous castrates is more potent than that of mere castrates indicates that some influence emanating from the cancerous growth itself is operating directly upon the pituitary anterior lobe.

It is an interesting fact, however, that with the onset of pregnancy in females with cancerous growths well started, or even of considerable size, the cancer development is commonly halted or retarded until the young are born, after which it usually resumes its growth. Such facts lead one to wonder if there may not be some germ of truth in the old suggestion of relationship between cancer and embryonic tissue. On the other hand, growing cancer does not inhibit follicular development, as does a growing fetus. Furthermore, according to Evans and Simpson ('29), the potency of the sex-stimulating secretions from the anterior lobe practically is unchanged in pregnant animals. Addison ('17) maintains that during pregnancy the oxyphiles instead of the basophiles increase in numbers.

SUMMARY

1. Bits of rat carcinoma when transplanted to young rats of our stock develop into active cancer in a high percentage of individuals (80 to 90 per cent).

2. Much the same structural and physiological changes in the anterior lobe—increased number of basophile cells, vacuolization of basophile cells, increased potency of the transplanted substance in stimulating ovarian size and sexual precocity—occur in cancerous individuals as those which follow castration of either males or females.

3. A Golgi-like apparatus is prominent in both basophiles and oxyphiles. The Golgi apparatus is closely associated with the formation of the vacuolar material of the basophile cells in both cancerous and castrate rats.

4. A distortion of the nucleus—usually an indentation on the side turned toward the Golgi apparatus—may occur in the larger and presumably older basophiles of either castrates or

cancerous individuals; in our preparations this condition is much more prevalent in the cancerous rats.

5. That some influence emanating from the cancerous growth operates directly upon the pituitary anterior lobe instead of through a sterilizing effect upon the gonad is indicated by the following facts: *a*) The estrual cycle shows little or no irregularity and cancerous animals will mate and bear young. *b*) No follicular atresia was found in rats with even advanced cancer. *c*) Transplanted anterior-lobe substance of cancerous castrates is more potent in stimulating ovarian growth and sexual precocity in immature rats and mice than is that of mere castrates.

LITERATURE CITED

- ADDISON, WILLIAM H. F. 1917 The cell-changes in the hypophysis of the albino rat, after castration. *J. Comp. Neur.*, vol. 28.
- EVANS, H. M., AND SIMPSON, M. E. 1929 A comparison of anterior hypophyseal implants from normal and gonadectomized animals with reference to their capacity to stimulate the immature ovary. *Am. J. Phys.*, vol. 89.
- GUYER, M. F., AND DANIELS, FARRINGTON 1928 Cancer irradiation with cathode rays. *J. Cancer Res.*, vol. 12.
- HATAI, S. 1913 The effect of castration; spaying or semispaying on the weight of the central nervous system and of the hypophysis of the albino rat. *J. Exp. Zool.*, vol. 15.

PLATE 1

EXPLANATION OF FIGURES

- 1 Photograph of a crater-like cancer in a rat.
- 2 Photograph under oil immersion of a section through the anterior lobe of the pituitary of a normal adult rat, showing three types of cells, basophiles, oxyphiles (deeply stained), and reserve cells.
- 3 and 4 Sections through the anterior lobe of the pituitary of a rat with cancer. Note the enlarged basophiles. Some are becoming vacuolated. The nucleus tends to be indented.
- 5 Section through the anterior lobe of the pituitary of a castrate rat. Basophiles are enlarged. Their difference in general appearance from the basophiles of 3 and 4 is due to a difference in the original photographic plate used.
- 6 Section through anterior lobe of a nine months' castrate rat. Basophiles are greatly vacuolated.

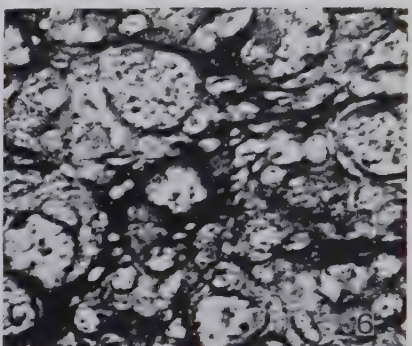
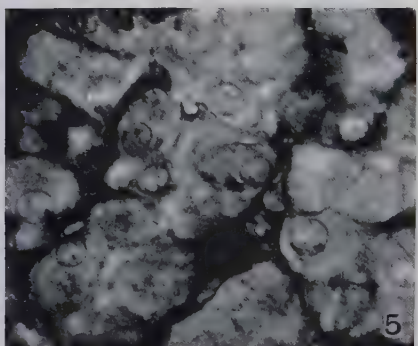
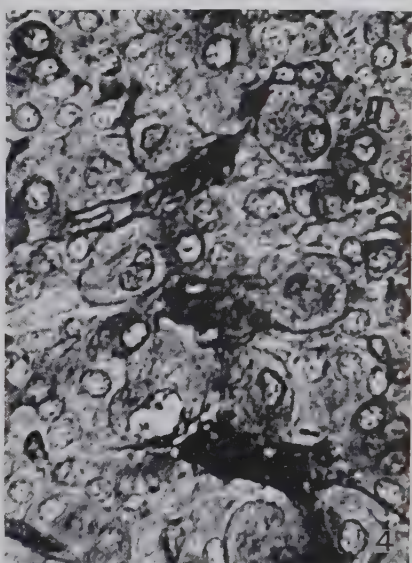
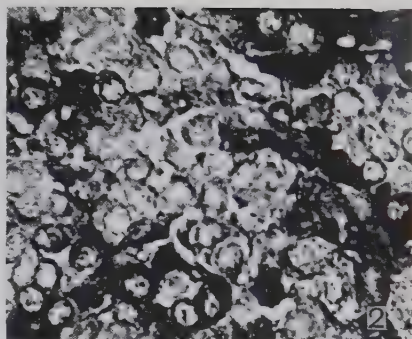
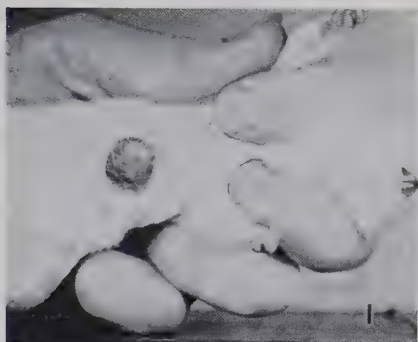


PLATE 2

EXPLANATION OF FIGURES

7 Camera-lucida drawing of an area of the anterior lobe of a normal rat. $\times 1125$.

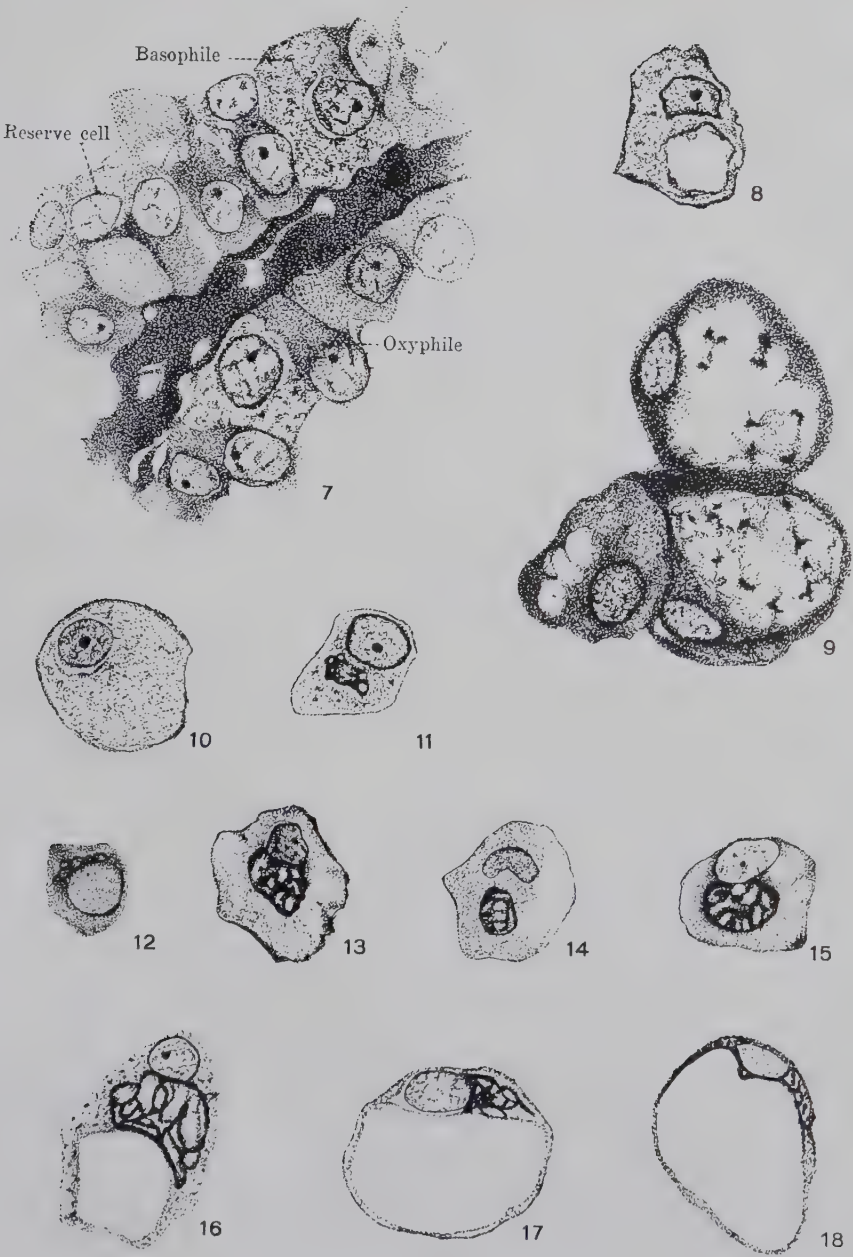
8 Camera-lucida drawing of a basophile from the anterior lobe of a cancerous rat. A vacuole has formed. $\times 1125$.

9 and 10 Camera-lucida drawings of basophiles from the anterior lobe of a castrate rat, showing different stages in the development of vacuoles. Figure 9 is more advanced. $\times 1125$.

11 and 12 Camera-lucida drawings of a basophile (fig. 11) and an oxyphile (fig. 12) from the anterior lobe of a normal rat, showing the position of the Golgi network. $\times 1125$.

13 and 14 Camera-lucida drawings of basophiles from the anterior lobe of a cancerous rat, showing the Golgi apparatus. In figure 14 a vacuole is forming and the nucleus is indented. $\times 1125$.

15 to 18 Camera-lucida drawings of basophiles from the anterior lobe of a castrate rat. Note the relationship of the Golgi body to the developing vacuole. $\times 1125$.



THE MEDIASTINAL GANGLION AND ITS RELATION TO THE INNERVATION OF THE THORACIC VISCERA¹

HARRY A. TEITELBAUM AND EDUARD UHLENHUTH
University of Maryland Medical School

FOUR FIGURES

While in the abdominal region the collateral sympathetic ganglia are, as a rule, condensed either into a single large ganglionic mass or into several smaller ganglia, the collateral sympathetic ganglia of the thorax are usually scattered throughout the mediastinal plexuses, and are frequently of microscopical size. With the above in view, it is a point of interest to present three cases in which a condensation similar to that existing in the abdomen occurred in the thorax—a condition which we will refer to as the ‘mediastinal ganglion.’

REVIEW OF LITERATURE

In searching the literature to determine whether previous observers noticed concentrations of nerve cells similar to the ganglion to be described here, we have not been able to find any records of an identical structure. The occurrence of other ganglia, however, has been reported.

The earlier anatomists paid a great deal of attention to a visible swelling of the vagus at the point of origin of the recurrent nerve. Brauecker(1), who reviews the older opinions concerning the latter structure, states that Haller (1762) denied its existence, while Vieussens and Willis confirmed its presence, as did Meekel (1817). Of particular

¹ The work reported in this paper was carried out with the support of the “Julius Friedenwald Fund for Medical Research” of the University of Maryland Medical School.

interest is a single case of a ganglion described by Lenhossek (2) ('90), which he refers to as an abnormal origin of the inferior laryngeal nerve. The latter arises from a fair-sized ganglion that lies in approximation to the dorsal surface of the aortic arch. There are communications between Lenhossek's ganglion and the inferior cervical and first thoracic ganglia, and the vagus trunk. Peripheral branches are distributed to the aorta, heart, oesophagus, and trachea. Lenhossek is of the opinion that this ganglion consists of sympathetic elements which have migrated from their usual position. This interpretation would classify the structure in question as a collateral sympathetic ganglion, similar in nature to the coeliac ganglion. Unquestionably, of all the ganglia described, Lenhossek's shows the closest similarity to the 'mediastinal ganglion,' to be described presently. From the distribution of the branches of Lenhossek's ganglion it is evident that in the innervation of the thoracic structures it played a rôle quite similar to that of the mediastinal ganglion. Unfortunately, however, Lenhossek failed to make a histological study of his finding to determine its true nature. It is therefore questionable as to whether it is a true ganglion.

In addition to the above-mentioned swelling there exists an intumescence on the vagus nerve at the level at which the pulmonary nerves arise. Brauecker, who confirms the presence of such a ganglion in his own dissections, also refers to some of the older anatomists who describe a similar swelling on the vagus; among these he mentions Wrisberg (1780), Swan ('34), Bourgery ('44), and Hirschfeld ('66), and states that Swan illustrates the swelling on one of his plates, that Bourgery names it 'portion plexiform et ganglionnaire,' and that Hirschfeld gave it the name 'Ganglion pulmonaire.' Upon comparison of Swan's(3) plate 3 with Hirschfeld's(4) plates 32-33 and 34-35, we found that Swan illustrates the swelling of the vagus at a point slightly caudate to the swelling illustrated by Hirschfeld. Little attention is paid by contemporary anatomists to this structure. Hovelacque(5) claims that inferior to the bronchus the vagus begins to

enlarge, and to break up into numerous fascicles, which if not completely dissected, might be mistaken for a swelling of the nerve trunk itself. Greving(6) writes that significant gangliform swellings have been observed at the level of the origin of the bronchial branches of the vagus. This enlargement has been observed many times in dissections carried out in our laboratory.

Besides the two vagus enlargements reviewed above, Remak (7) found numerous small ganglia on the fine bronchial nerve fibers in the ox. Brauecker(1), with reference to Remak's finding, states that similar conditions have been described in other animals and in man. In addition he mentions that Walter observed small ganglia in the course of nerves that gave rise to oesophageal fibers. Greving(6) also writes of small ganglia in the anterior and posterior pulmonary plexuses. Kandarazki(8) described ganglia in the nerve fibers which pass along the bronchi; he mentions them as being present in the cat, sheep, squirrel, and dog, as well as in man. In the dog, Kandarazki describes tracheal ganglia that are scattered in the plexus lying on the dorsal membranous portion of that organ. In man the ganglia are only sometimes present; and then only in limited numbers on the dorsal aspect of the bifurcation of the trachea. Tscheliustkin (9) also describes numerous small ganglia which lie superficially on the dorsal membranous portion of the trachea of the dog. In addition, a 'supreme thoracic ganglion' is described in the same animal at the level of the first intercostal space. This ganglion lies at the point of junction of a nerve from the inferior cervical ganglion and one from the stellate ganglion. A number of smaller ganglia may replace a single larger one. Branches that arise from the 'supreme thoracic ganglion' pass to the pericardium, aorta, and trachea. Kondratjew(10) describes a 'supreme thoracic ganglion' in the infant. The branches, the author writes, do not pass to the organs directly as in animals, but by the intermediation of a nervous plexus. The distribution of the branches of the 'supreme thoracic ganglion' is suggestive of

a similarity in nature between it and the mediastinal ganglion, described in this paper.

THE ANATOMY OF THE MEDIASTINAL GANGLION

The mediastinal ganglion was located, in every one of three cases, in the posterior mediastinum, to the left of the median line, just caudate and dorsal to, or in contact with, the caudate border of the root of the left lung, between the root of the left lung and pericard ventrally and the descending thoracic aorta and oesophagus dorsally. In order to locate it in a dorsal dissection, both the aorta and oesophagus should be pulled to the right and the left vagus nerve should be followed as it crosses the dorsal surface of the left pulmonary root.

The ganglion has a variable shape; in the cadaver it is flattened dorsoventrally. At first sight it appears to be a part of the plexus which connects the two vagi at the site of the origin of the posterior pulmonary plexuses.

Although in none of the three cases a sufficiently careful dissection could be carried out to assure us that all the branches arising from and joining the ganglion had been found, the branches actually displayed indicate that the ganglion supplies more than one organ.

In the newborn infant (fig. 1) eight individual rami radiate from the ganglion; these and their branches may be grouped into four different kinds. Some of the branches supply the bronchi, others the trachea, still others the oesophagus, and again others connect the ganglion with the vagus nerves. The latter branches are the most numerous; they connect the ganglion with both the left and right vagi as well as with the interpulmonary plexus.

In the adult (fig. 2) at least six individual rami may be said to radiate in all directions from the ganglion. There are three kinds of branches, one group supplying the left bronchus, another group supplying the oesophagus, and a third group establishing communication between the ganglion and the vagi nerves (left and right vagi and interpulmonary plexus).

In a second adult (fig. 3) the ganglion possessed six rami; these supplied the oesophagus and established communications with the left vagus and interpulmonary plexus.

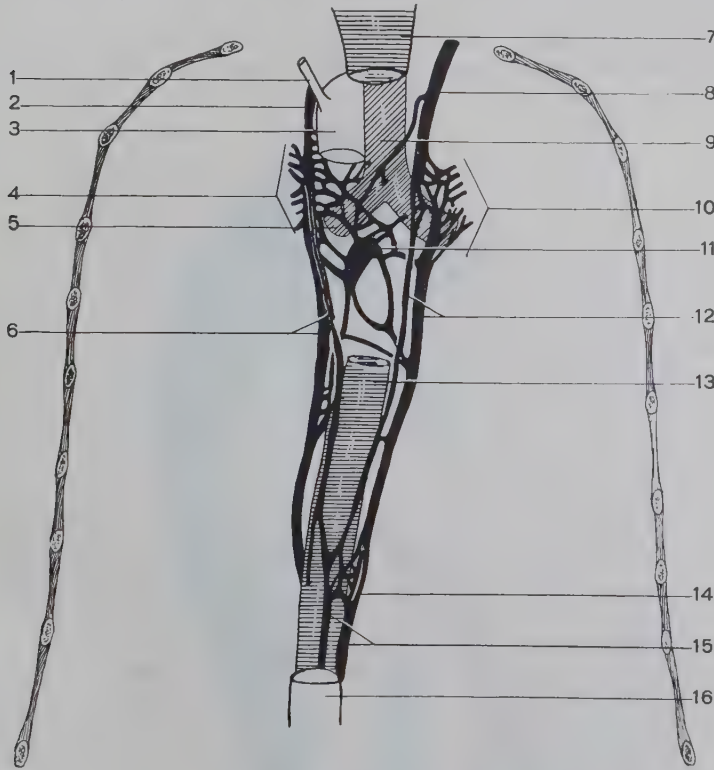


Fig. 1 The mediastinal ganglion (11) of a newborn infant, displayed in a dorsal dissection. The dorsal thoracic wall has been removed; the dorsal surfaces of the oesophagus (7, 13), of the left subclavian artery (1), of the descending aorta (3, 16), of the trachea (9), and bronchi (5) are visible. Both the aorta and oesophagus are cut and partly removed to expose the interpulmonary and ventral oesophageal plexuses and the mediastinal ganglion. The left (2) and the right (8) trunks of the vagi are giving off the pulmonary plexuses at 4 and 10, and are breaking up into the long medial oesophageal rami 6 and 12, which contribute to the dorsal vagus cord (15). The mediastinal ganglion is located just caudate to the left bronchus (5) and slightly to the left of the median line, dorsal to the pericard and ventral to the aorta and oesophagus. Eight rami are radiating from it in all directions, supplying the trachea and bronchi and joining both vagi and the interpulmonary and ventral oesophageal plexuses.

That the structure in question is really a ganglion, and not merely an accumulation of nerve fibers, becomes evident from histological sections, in which large multipolar cells (fig. 4) were found.

Considering the three dissections together, we may say, then, that the mediastinal ganglion possesses rami passing

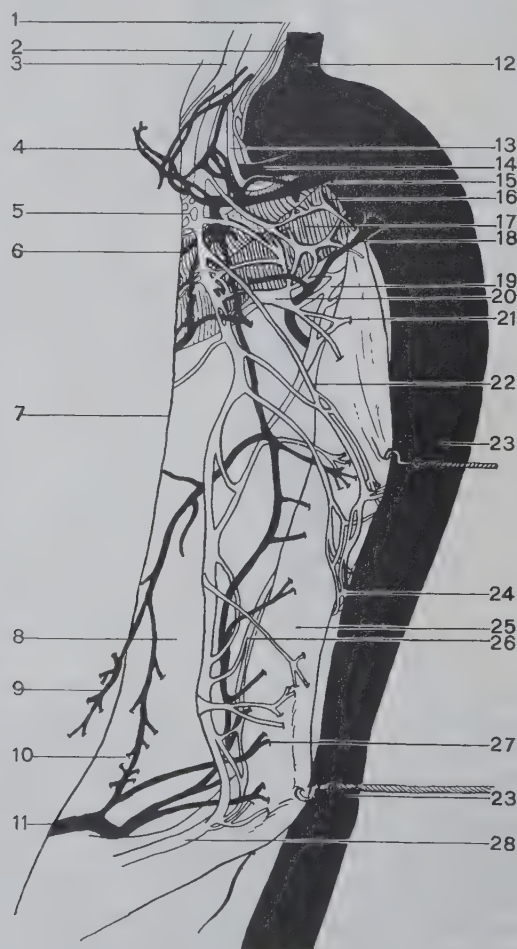


Figure 2

to four different structures, to the vagi nerves, trachea, bronchi, and oesophagus.

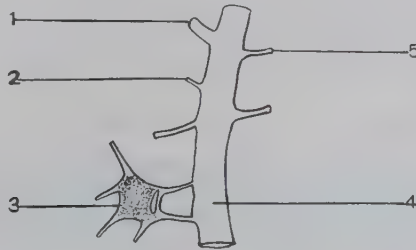


Figure 3

Fig. 2 The mediastinal ganglion (20) of an adult American negro male, aged fifty-one years. The dorsal wall of the thorax has been removed. One is looking into a space which is bordered on the left by the border of the left pleural sacs (7), on the right by the descending thoracic aorta (23) and oesophagus (25), both of which have been pulled to the right side. The craniate border of the space is formed by the aortic arch with the left subclavian artery (12) and the ligamentum arteriosum (14). The cervical cardiac branches (1 and 2) and the left recurrent nerve (13) are seen on the aortic arch. The floor of the space is formed by the left pulmonary root (bronchus, 7) and by the dorsal surface of the pericard (8). The mediastinal arteries (15 and 18), the inferior phrenic artery (11), and the branches and anastomoses (4, 6, 9, 10, and 27) are illustrated in black. The left vagus gives off the pulmonary plexus (at 5), a bronchial nerve (16), and the long medial oesophageal rami (22, 24), and becomes, after receiving ventral long medial branches from the right vagus (19 and 26) the ventral cord of the vagus (28). The mediastinal ganglion (20) is located upon the dorsal aspect of the caudate border of the left bronchus, to the left of the median line and ventral to the oesophagus and aorta (both of which have been pulled to the right). Six rami radiate from it, innervating the left bronchus and the oesophagus (21) and establishing extensive connection with the interpulmonary and ventral oesophageal plexuses and with both vagi.

Fig. 3 The mediastinal ganglion of a white adult male, aged seventy-five years, shown from a ventral aspect. The ganglion (3) possesses six rami; four of these pass to the oesophagus and interpulmonary plexus, the other two establish connections with the left vagus (4). 1, 2, and 5 are branches of the left vagus, representing the left recurrent nerve (1), an anastomosis with the interpulmonary plexus (2), and branches to the posterior pulmonary plexus (5).

AN INTERPRETATION OF THE MEDIASTINAL GANGLION

From the evidence presented above it seems obvious that in a certain number of individuals a conspicuously large ganglion is present in the thorax, possessing in every case

the same gross anatomical features. Particularly conspicuous is the location of the ganglion, which was found to be practically the same in every one of the three cases recorded.

The question that remains to be answered concerns the nature of the ganglion; whether it is sympathetic or parasympathetic.

Fairly convincing evidence in favor of the sympathetic nature of the ganglion would be furnished by a case in which one or several direct branches connecting it with the sympathetic trunk were present. Such a case has not been available as yet. In the absence of the latter, findings which have a bearing on the possible existence of pathways between the sympathetic trunk and the mediastinal structures are of interest. It is a well-established fact that sympathetic branches are given off by the thoracic portion of the sympathetic trunk to anastomose with the pulmonary, oesophageal, and cardiac plexuses. Especially constant seems to be a large branch arising from the first or second thoracic ganglion, and passing to the pulmonary and cardiac plexuses. This branch was described by Hirschfeld, and was named the 'pulmonary splanchnic' in consideration of its close resemblance to the splanchnics. We have been able to confirm the existence of this nerve in our own laboratory.² Brauecker(1) has confirmed the observations of the older anatomists with regard to the existence of numerous ventral branches which arise from the thoracic sympathetic trunks and pass into the mediastinum, where they establish connections with the pulmonary, oesophageal, and cardiac plexuses (mediastinal branches); some of these branches arise directly from the rami communicantes and spinal nerves, indicating that at least some of the fibers contained in these mediastinal rami are of pre-ganglionic nature; a fact which calls for the existence of a collateral sympathetic ganglion in the mediastinum. Ganglia corresponding to this description are the often microscopically small nodules that are scattered throughout the mediastinal

² A preparation which showed the pulmonary splanchnic in an especially striking manner was made by Messrs. L. H. Feldman and J. H. Rabinowitz in our laboratory, summer of 1931.

plexuses. It should be mentioned here that Brauecker does not consider these fibers as sympathetic in nature, but thinks that they are spinal components of the vagus nerve, which radiate from the thoracic segments to their terminations, where they synapse with postganglionic neurons. Evidence for this contention, however, appears to be insufficient as yet.

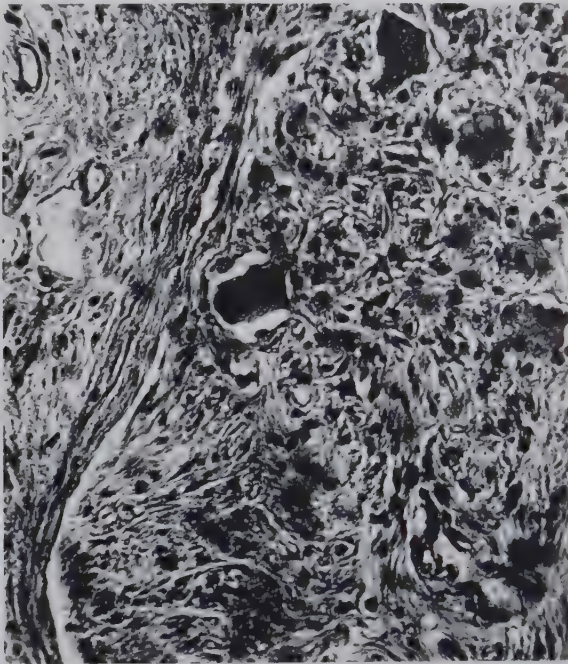


Fig. 4 A histological section through the mediastinal ganglion illustrated in figure 3 and showing the multipolar nerve cells of the ganglion:

The mediastinal rami are gross anatomical pathways along which preganglionic sympathetic fibers may travel from the spinal cord, either directly, or through the intermediation of the sympathetic trunks and mediastinal plexuses, to the mediastinal ganglion, or any other collateral sympathetic ganglia in the thorax.

An additional fact suggesting the sympathetic nature of the mediastinal ganglion presents itself in the general plan of distribution exhibited by the branches of the ganglion. While parasympathetic ganglia, as a rule, are either incorporated in the organs which they supply, or lie close to the latter, and distribute their fibers to only a single organ or even organ portion (intramural plexus ganglia), the mediastinal ganglion sends branches to several organs (trachea, bronchus, oesophagus), corresponding in this respect to the condition usually found in sympathetic ganglia.

It is consistent with the above-mentioned facts to consider the mediastinal ganglion as sympathetic in nature. Since there are some individuals in whom the numerous small sympathetic ganglia, usually scattered about in the mediastinal plexuses, have been concentrated into a larger ganglion, a condition exists in these individuals which is comparable to that found in the abdomen in a large majority of the cases. The mediastinal ganglion of the thorax may be compared, therefore, to the coeliac ganglion of the abdomen.

In view of the increasing trend toward condensation exhibited by the nervous systems of the higher vertebrate forms as compared with those of the lower forms, the condensed condition of the collateral sympathetic neurons in the thorax might be considered as a more advanced evolutionary stage in the development of that portion of the sympathetic nervous system.

LITERATURE CITED

- 1 BRAUECKER, W. 1927 Der Brustteil des vegetativen Nervensystems und seine klinisch-chirurgische Bedeutung. Beiträge zur Klinik der Tuberculose, Bd. 66, S. 1-65.
- 2 VON LENHOSSEK, M. 1890 Abnormer Ursprung des N. laryngeus inferior. Anat. Anz., Bd. 5, S. 230.
- 3 SWAN, J. 1834 A demonstration of the nerves of the human body. London.
- 4 HIRSCHFELD, L. 1866 Traité et iconographie du system nerveux. 2nd ed., Paris.
- 5 HOVELACQUE, A. 1927 Anatomie des nerfs craniens et rachidiens et du système grand sympathique, pp. 215-216. Gaston Doin & Cie, Paris.
- 6 GREVING, R. 1931 Allgemeiner Aufbau und makroskopische Anatomie des vegetativen Nervensystems; in L. R. Müller's 'Lebensnerven und Lebenstrieb,' S. 3, Berlin.

- 7 REMAK, R. 1844 Neurologische Erläuterungen. Müller's Arch. f. Anat., Physiol., u. wiss. Med., S. 464.
- 8 KANDARAZKI, M. 1881 Ueber die Nerven der Respirationswege. Arch. f. Anat. u. Entwicklungsgesch., S. 1-11.
- 9 TSCHELIUSTKIN, M. N. 1927 Über die Innervation der Trachea und der Bronchien beim Hunde. Zeitsch. f. Anat. u. Entwicklungsgesch. (Abt. I der Zeitsch. f. d. ges. Anatomie), Bd. 83, S. 605-614.
- 10 KONDRATJEW, N. S. 1926 Ueber akzessorische Nervenorgane in der Brusthöhle beim Menschen. Anat. Anz., Bd. 61, S. 69-77.

CLEAVAGE AND CYTOPLASMIC ELIMINATION IN THE ARMADILLO ¹

G. W. D. HAMLETT

Department of Zoölogy, Indiana University

FIVE TEXT FIGURES AND TWO PLATES (EIGHT FIGURES)

INTRODUCTION

It is the purpose of this paper to give a description of a few cleavage stages from the Texas armadillo, *Tatusia novemcincta*, and to describe a process of 'yolk elimination' more extreme than anything heretofore reported for placental mammals. The material available is very scanty, consisting of five tubal ova collected during the summer of 1928. As has been pointed out elsewhere (Hamlett, '32), ovulation in this form occurs about the middle of July. A series of eighty-nine females was killed between July 4th and July 16th; nineteen of these showed a corpus luteum in one ovary, but had no blastocyst in the uterus. For each of the latter, the tube from the ovulating side was sectioned and examined for ova, the search proving successful in five cases. As there seems to be no immediate prospect of adding to the series, it has been decided to publish the results to date, even though they are disappointingly meager.

DESCRIPTION OF MATERIAL

Specimen no. 763. July 16, 1928. Four-cell ovum. Located approximately one-third of the distance down the tube from the ostium. (Figs. 1, a, b, and c; 6 and 7.)

¹ This paper represents contribution no. 224 from the Zoölogical Laboratories of Indiana University. Collection of the material on which the paper was based was made possible by a grant from the Bache Fund and by grant no. 60 from the Waterman Institute of Indiana University. I wish to express here my appreciation of the support received from these sources.

The ovum, measuring in section $90 \times 95 \mu$, is partially surrounded by a mass of compacted follicular cells. It appears on three sections cut at 25μ ; the photomicrographs shown are taken from the second and third of these. The cells have been arbitrarily lettered for convenience in referring to them. In figure 1, a, cell *a* has been cut through the middle and this section gives a true picture of the size of this cell. Cell *b* appears in two figures. In 1, a, the full size of the cell is not shown, and only a part of the nucleus appears in the section. Figure 1, b, shows the remainder of the nucleus in a section through the center of the cell. This section shows *b* to be similar in size to *a*. Cell *c* appears in all three figures, a partial section in 1, a, and more central sections in 1, b, and 1, c. The latter sections show this blastomere to be much larger than *a* and *b*. The fourth cell, *d*, is seen in figures 1, b, and 1, c. The last section through the ovum shows *d* to be approximately equal in size to *c*.

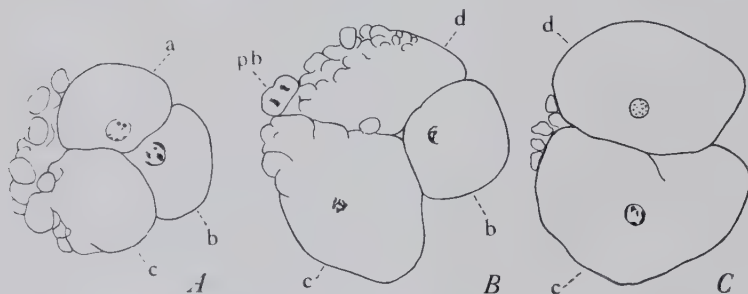


Fig. 1 Ovum 763, four-cell stage. Camera-lucida drawings of the three sections. $\times 395$.

The smaller cells, *a* and *b*, have sharp and definite outlines. Portions of the cell membranes of *c* and *d* are likewise distinct and unbroken, but in places the margins, particularly of *d*, appear to be crumbling away; a good part of the periphery of the cell is made up of rounded fragments of cytoplasm that are separating from each other and from the blastomere proper. Some of these masses are just fragmenting; others seem to have rounded up and formed distinct membranes. The bilobed mass in figure 1, b, labeled *p.b.* is possibly one of the polar bodies; it differs from all other bodies in having chromatic material.

Specimen no. 741. July 9, 1928. Four-cell ovum. The tube in this animal was so convoluted that it is difficult to judge of the exact position of the ovum. It is apparently between one-third and one-half of the distance down the tube. (Figs. 2, a and b; 8 and 9.)

This ovum, which measured $89 \times 98 \mu$, appears in four sections cut at 25μ ; the second and third of these sections are figured in the text and on the plate. In general, this ovum is like the preceding one, but there are certain noticeable differences. The blastomere labeled *a* is markedly smaller than any of the others, and is smaller than *a* and *b* in ovum 763. Cell *b* is larger than *a*, but in turn is considerably smaller than *c* and *d*, which seem to be of about equal size.

In this ovum, the peripheral fragmentation of the larger blastomeres, that was so conspicuous a feature of the preceding egg, seems to be coming to a close. A large number of the cytoplasmic fragments are present, but most of them show distinct membranes, and the blastomeres themselves have fairly definite outlines, in striking contrast to the appearance presented by *c* and *d* of ovum 763. With

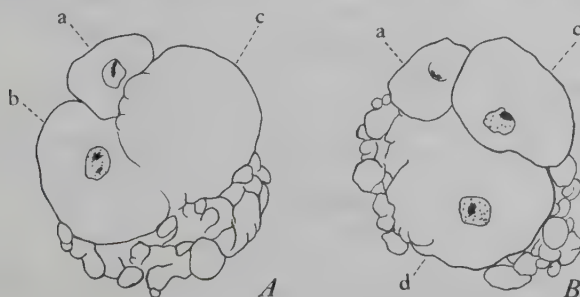


Fig. 2 Ovum 741, four-cell stage. Camera-lucida drawings of the second and third of four sections. $\times 395$.

respect to this process, the present specimen must be further advanced than the preceding one, although the number of blastomeres is the same.

Specimen no. 744. July 9, 1928. Ten-cell ovum. Tube very convoluted, ovum in upper half. (Figs. 3, a, b, and c; 10 and 11.)

The blastomeres appear on three sections cut at 25μ , although a fourth section shows some of the cytoplasmic fragments that were seen in the four-cell ova. The section shown in figure 3, b, measures $74 \times 95 \mu$. The photographs given are of the second of the three sections.

This specimen is interesting because of ovarian elements found along with the ovum. Not only are there a few clumps of granulosa cells (corona radiata) close to the ovum, but there are connective-tissue cells, epithelial cells singly and in masses, degenerating oocytes, and even a few intact primary graafian follicles. Something of this

is shown in figure 10. Apparently the rupture of the follicle was accompanied by a much greater disturbance of the surrounding tissues than is usual.

The ovum itself seems perfectly normal in spite of its unusual company. Most of the extrusions are massed toward one side of the ovum and appear in the fourth section, which is not figured. There are noticeable differences in the size of the blastomeres, but it is impossible to say what relation these different-sized cells bear to the large and small cells of the four-cell stage. Cleavage is no longer synchronous, since some blastomeres have evidently divided precociously to give the ten cells found here.

Specimen no. 739. July 9, 1928. Twenty-cell morula. More than halfway down the tube. (Figs. 4, a, b, c, and d; 12.)

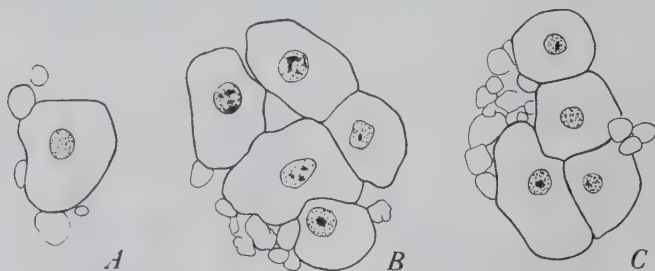


Fig. 3 Ovum 744, ten-cell stage. Camera-lucida drawings of the three sections through the blastomeres. $\times 395$.

The ovum appears in four sections cut at 25μ . The third of these sections measures $78 \times 97\mu$. The plate figure shown is of this section. Since a number of nuclei were cut through in sectioning, it is rather difficult to be certain of the exact cell number. A careful check gives twenty as the probable number, with a possibility that the true number might be one more or less.

The cytoplasmic fragments are very conspicuous and numerous in this ovum. Differences in cell size are still obvious, but a study of the sections fails to show any relation between the size of the blastomeres and their position in the morula.

It is to be noted that this ovum does not show any of the ovarian cells, coronal or otherwise, that were seen in the preceding stages.

Specimen no. 743. July 9, 1928. Small blastocyst. Approximately three-fourths of the distance from ostium to uterus. (Fig. 5.)

The blastocyst is so badly collapsed that it is impossible to photograph successfully. The text figure is semidiagrammatic, but the inner cell mass was drawn under the camera lucida. Essentially

this vesicle is like the uterine vesicles described by Patterson, differing only in its much smaller size and lesser number of cells. Allowing for the folding of the blastocyst wall, the vesicle seems to be only about a third the size of the average uterine blastocyst, that is to say, about

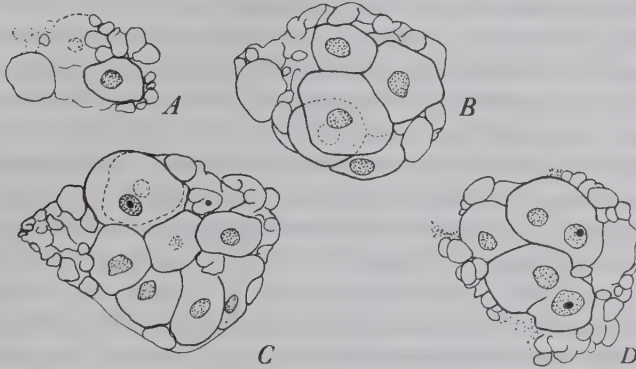


Fig. 4 Ovum 739, twenty-cell stage. Camera-lucida drawings of the four sections. $\times 395$.

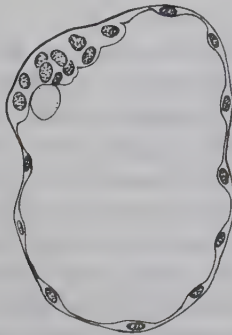


Fig. 5 Ovum 743, tubal blastocyst. Inner cell mass drawn under camera lucida; subzonal layer shown as if vesicle were expanded (in the actual specimen it is badly collapsed). $\times 395$.

120 μ in diameter, as against 375 μ . In correlation with this lack of expansion, the trophoblast cells are much less flattened than in the uterine vesicles. The inner cell mass is quite small, containing only about a dozen cells. It will be noted that the size of this blastocyst is but slightly greater than that of the cleavage stages.

There are a few general points in the foregoing paragraphs to which attention may be called. In the first place, the diameter of the fixed ovum varies between 80μ and 100μ , the shape of the cleavage stages never being perfectly spherical. There is no trace whatever of a zona pellucida from the four-cell stage on, and it is doubtful if the freshly discharged egg has one. It would seem impossible for it to disappear so quickly. A considerable number of follicular cells are discharged along with the oocyte; by the time of the second cleavage these have lost the arrangement of the typical corona radiata and appear as compacted masses of degenerating cells, lying near or around the segmenting ovum (fig. 13). They have already completely disappeared in the single twenty-cell stage available for study. Lastly, the four-cell stage shows the typical crossed arrangement of the two pairs of blastomeres that seems to be characteristic of the ovum of the Eutheria and of the opossum.

DISCUSSION

The above stages, few as they are, enable us to draw certain conclusions as to the manner of cleavage in the armadillo. In the first place, it is evident that one of the first two cleavages is markedly unequal. In one of the four-cell ova studied, we find two large and two small cells, the larger cells being more than twice the size in volume of the smaller. In the other four-cell ovum, there is one small, one medium-sized, and two large cells, the large cells being several times the volume of the small one. This disparity in cell size is much greater than that reported for other mammals. Hill and Tribe find a slight difference in size in the two-cell stage of the cat, while Heuser and Streeter report a difference in volume of the four cells of the second cleavage in the pig amounting to a 3:2 ratio between large and small. Considerable inequality in size can still be noted in the ten-cell and twenty-cell stages of the armadillo. In recent years there have been several attempts at working out a 'cell lineage' for the mammals, and the difference in size of the blastomeres has been

the principal criterion for tracing differentiation. Heuser and Streeter conclude that in the pig the originally larger but more rapidly dividing, and hence eventually smaller, cells form trophoblast; those which were smaller at first, but which divide more slowly, and consequently become proportionately the larger, forming the inner cell mass. In the cat, Hill and Tribe trace the origin of the differentiation between inner cell mass and trophoblast to a shifting of blastomeres which brings one or two cells of the sixteen-celled stage into a central position. These central cells are usually larger than the others and become the inner cell mass. Now in the armadillo, while there are conspicuous differences in the sizes of the blastomeres, there is no definite relation between their size and their position.

If we are correct in interpreting the body labeled *p.b.* in figure 2 as a polar body, then the armadillo would appear to agree with *Dasyurus* and the bat in extruding the polocytes at the deutoplasmic pole of the ovum. However, while Hill believes that this represents the animal pole of the egg, Van der Stricht holds it to be the vegetal pole, and a comparison with these forms would not seem to help in interpreting the condition in the armadillo. On theoretical grounds, it would seem logical to think that the smaller cells of the four-cell stage represent the animal pole of the ovum, while the larger blastomeres which eliminate part of their cytoplasm lie at the vegetal pole. This would bring the armadillo into harmony with Van der Stricht's findings in the bat.

The ten-cell and twenty-cell stages of the armadillo still show a marked difference in size between some of the cells, but it is impossible to judge on the basis of the available material whether these size differences have anything to do with the future fate of the cells. There does not seem to be any arrangement of the cells according to size, large ones and small ones being mingled in a haphazard fashion. It may be that this lack of relation is only apparent, due to insufficient material; or it may be that the differentiation into trophoblast cells and embryonic cells takes place later in this form than it does in the pig or the cat.

The most striking feature exhibited by the armadillo ovum is its conspicuous elimination of cytoplasmic material during the early cleavages. This elimination is accomplished by a method that is unique so far as is known. In the four-cell stage the two larger blastomeres seem to break up around their outer edges and pieces of the cytoplasm crumble away in distinct masses. There is no resemblance at all of these discrete fragments to the finely granular substance which various workers have described as lying around the blastomeres in many other mammals. Neither does the term 'deutoplasmolysis,' which Van der Stricht first used for the bat and which has been tentatively accepted by Hill and Tribe for the cat, seem to quite describe the origin of the extruded cytoplasmic masses. Van der Stricht's figures do not give any clear idea as to the method of extrusion of the deutoplasmic masses. In his description of the process he speaks in one place of the forming of buds ('bourgeons, lobules vitellins') from the surface of the egg and elsewhere speaks of these extrusions as being made up of clear vacuoles ('formés de vacuoles claires'). Apparently the bat is more primitive than the armadillo in that it forms readily distinguishable semifluid deutoplasm quite unlike the remaining cytoplasm, and it is this semifluid deutoplasm that is expelled from the egg. Now in the armadillo, the cytoplasm of the blastomeres is at least superficially homogeneous, and it does not seem to show any of the plasticity or even ameboid behavior which Van der Stricht thinks is responsible for the extrusion of deutoplasm from the bat ovum. I have accordingly hesitated to use the term 'deutoplasmolysis,' as it does not seem to fit the conditions found in the armadillo. 'Fragmentation' would seem to be the term best descriptive of the formation of the extruded masses, and it should be noted that these seem to be as purely cytoplasmic as is the remainder of the blastomere. These fragments are still to be observed in the ten-cell and twenty-cell ova, although the process which gave rise to them does not seem to be operating any longer. In the ten-cell stage (and to a large extent in one of the four-cell

ova) the cell membranes of the blastomeres are complete and unbroken and their outlines are even and distinct. The expelled fragments of cytoplasm also seem to have formed distinct membranes. The twenty-cell ovum shows the same conditions. These eliminated cytoplasmic bodies apparently disappear rather rapidly, for there is no trace whatever of them around the tubal blastocyst.

There are certain theoretical considerations which may be drawn from the foregoing facts, aided and supported by work done on other forms. It is almost universally conceded that the ancestor of the Eutheria developed from a heavily yolked egg, and we find the monotremes still possessing a yolk-laden, meroblastic ovum. The marsupials have lost most of the yolk in the course of their evolution, but still retain in their ovum an amount of yolk large enough to necessitate its elimination before cleavage can be carried out. In Didelphys this is brought about by the formation of new cell walls around the yolk-free cytoplasm and within the limits of the original egg membrane—a process which is, of course, exactly what happens in the meroblastic cleavage of reptile and bird. In the placental mammals the yolk is at a minimum and does not interfere with cleavage. Nevertheless, we have in the armadillo egg an expulsion of part of the cytoplasm—a process which must be a persistence from the time when its ancestors still possessed an encumbering amount of yolk. It is to be noted that this 'yolk extrusion' takes place only from the two large blastomeres, that is to say, from what probably represents the vegetal pole of the ovum. In the bat, Van der Stricht likewise finds deutoplasmolysis taking place at what he interprets as the vegetal pole. It would seem that the bat and the armadillo are essentially alike in this phenomenon, although the exact method by which the process is carried out differs in the two forms. This difference is probably due to differences in the amount and kind of deutoplasmic material, and is not of fundamental importance.

SUMMARY

1. In its general outlines, irregularity of division, arrangement of blastomeres, etc., the cleavage of the armadillo ovum agrees with that of other placentates.

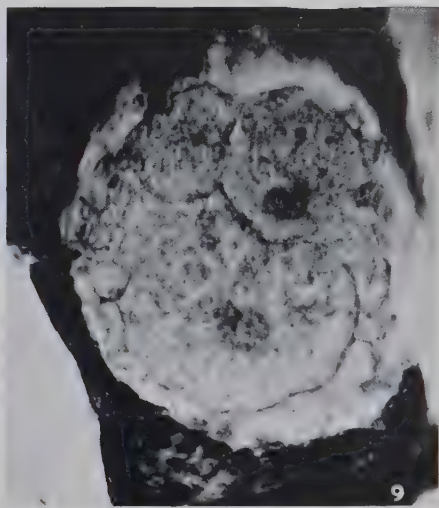
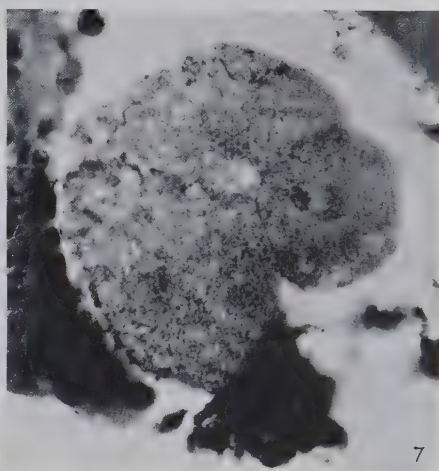
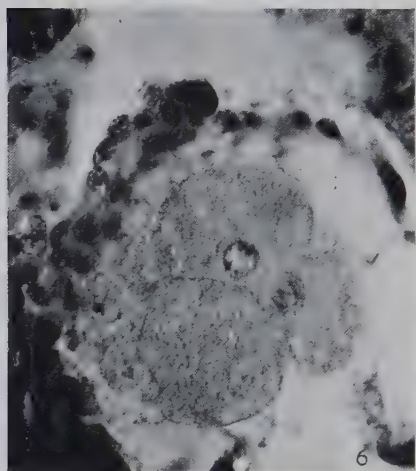
2. The egg, as seen in the four-cell stage, is between 80 μ and 100 μ in diameter, shows no zona pellucida, but is accompanied by a large number of extruded granulosa cells.

3. One of the first two cleavages is markedly unequal, the two larger blastomeres being at least twice the size of the two smaller ones.

4. A considerable amount of cytoplasm fragments from the free edges of the two large blastomeres of the four-cell stage. This process is interpreted as being a reminiscence of an ancestral process of yolk extrusion, such as is found in living marsupials.

LITERATURE CITED

- HAMLETT, G. W. D. 1932 The reproductive cycle in the armadillo. Zeit. f. wiss. Zool. (in press).
- HARTMAN, C. G. 1916 Studies in the development of the opossum, *Didelphys virginiana* L. I. History of the early cleavage. II. Formation of the blastocyst. J. Morph., vol. 27.
- HEUSER, C. H., AND G. L. STREETER 1929 Early stages in the development of pig embryos, from the period of initial cleavage to the time of the appearance of limb-buds. Carnegie Inst. Wash., Contr. to Emb., vol. 20.
- HILL, J. P. 1910 The early development of the Marsupialia, with special reference to the native cat (*Dasyurus viverrinus*). Q. J. M. S., vol. 56.
- HILL, J. P., AND MARGARET TRIBE 1924 The early development of the cat (*Felis domestica*). Q. J. M. S., vol. 68.
- PATTERSON, J. T. 1913 Polyembryonic development in *Tatusia novemcincta*. J. Morph., vol. 24.
- VAN DER STRICHT, O. 1910 La structure de l'oeuf des mammifères (*Chauve souris*) *Vesperugo noctula*. Troisième partie: L'oocyte à la fin du stade d'accroissement, au stade de la maturation, au stade de la fécondation et au début de la segmentation. Mém. de l'Acad. roy. de Belgique, série II, T. 2.

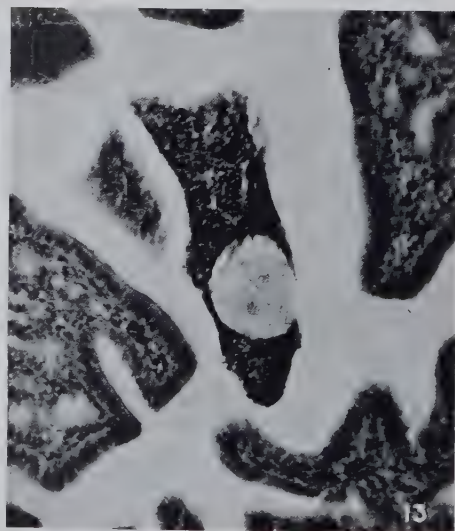
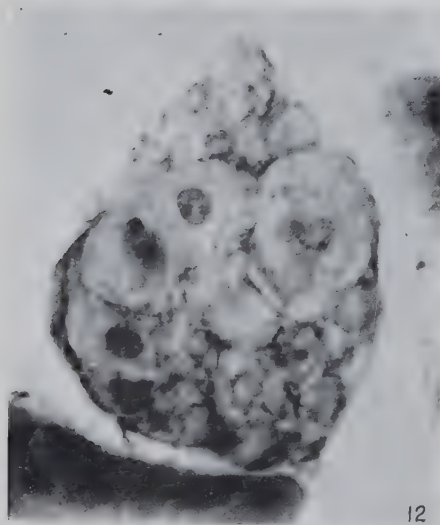
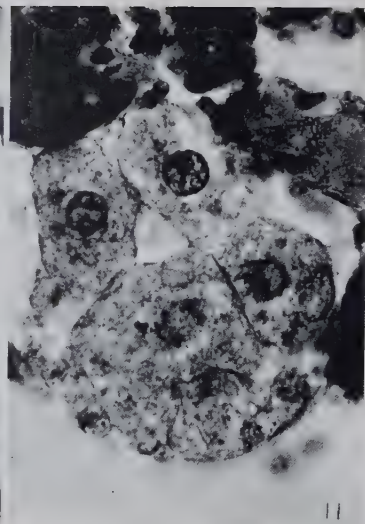
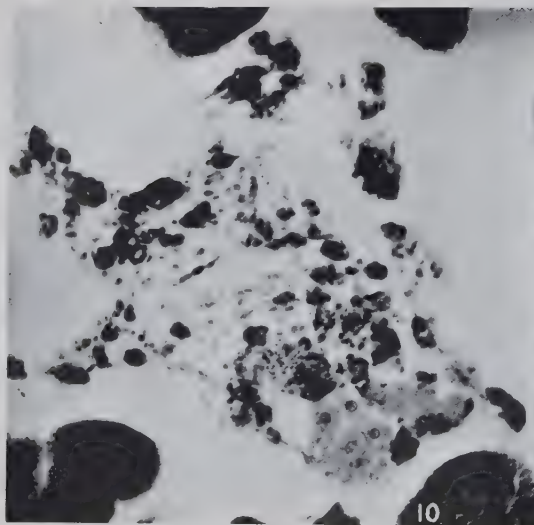


6 Four-cell stage, ovum 763. Same section as figure 1, a. The ovum is partly surrounded by follicular cells. $\times 500$.

7 Another section of ovum 763. Figure 1, b, shows this same section. $\times 500$.

8 Four-cell stage, ovum 741. Same section as figure 2, a. The blastomeres appear completely surrounded by follicular cells. $\times 500$.

9 Same ovum as figure 8. This section is shown in figure 2, b. $\times 500$.



10 Ovum 744, ten-cell stage. This section shows the ovum toward the bottom of the figure, near the folds of the tubal mucosa. Large numbers of ovarian cells of various kinds partly fill the cavity of the fallopian tube. $\times 140$.

11 The ten-cell ovum shown in figure 10. $\times 500$.

12 Ovum 739, twenty-cell stage. This is the section shown in figure 4, c. Note the ciliated tubal mucosa below and to the right of the ovum. $\times 500$.

13 A low-power view of the section shown in figure 9, to show the appearance of the follicular cells after the corona radiata has begun to degenerate. $\times 140$.

PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

FORTY-EIGHTH SESSION

*College of Physicians and Surgeons, Columbia University,
New York City, March 24, 25, and 26, 1932*

THURSDAY, MARCH 24, 1932

10.00 a.m. The Forty-eighth Session of the American Association of Anatomists was called to order by President Herbert M. Evans, who appointed the following committees:

Auditing Committee: Professor Wayne J. Atwell, Chairman; Professor Earl T. Engle.

Nominating Committee: Professor Richard E. Scammon, Chairman; Professor George B. Wislocki, Dr. Stacy R. Guild.

The remainder of the session was devoted to the presentation of scientific papers.

FRIDAY, MARCH 25, 1932

12 noon. Business meeting, President Herbert M. Evans in the chair. The Secretary reported that the minutes of the Forty-seventh Session were printed in *The Anatomical Record*, volume 49, no. 2, pp. 149-154, inclusive. On motion, seconded and carried, the minutes were approved as printed.

Report of the Treasurer: The Treasurer made the following report for the year 1931:

Balance on hand, December 31, 1930 (last audit of accounts) ..	\$1259.28
Receipts from dues, 1931	507.07
Interest on deposits	32.20
Total credits	\$1798.55

Expenditures, 1931:

Stamps and postage	\$ 73.74
Stationery	12.82
Printing and addressing	78.22
Programs, 47th meeting	128.00
Office equipment	54.20
Secretarial services	18.70
Traveling expenses, secretary	63.64
Telegrams and express	18.63
Collection fees, dues refunded, checks returned	7.00
Local committee, Chicago	150.00
Committee, Amsterdam Congress	100.00
Appropriation, Biological Abstracts	100.00

Total expenditures	804.95
--------------------------	--------

Balance on hand December 31, 1931, and deposited in the name of the American Association of Anatomists, in the Lincoln- Alliance Bank and Trust Company, Rochester, New York....	\$993.60
--	----------

Report of the Auditing Committee: Professor Wayne J. Atwell reported as follows:

"The undersigned Auditing Committee has examined the accounts of the Secretary-Treasurer for the year 1931, and finds total receipts to be those entered in the journal, expenditures in accordance with receipted bills, and the balance on hand December 31, 1931, in agreement with the bank statement of that date."

[Signed] WAYNE J. ATWELL,
EARL THERON ENGLE.

On motion, duly seconded, the reports of the Treasurer and of the Auditing Committee were accepted and adopted.

Amendments to the Constitution: The Secretary announced that the following proposed changes in the Constitution were

submitted in writing at the Forty-seventh Session, and due notice thereof was sent to the members on March 10, 1932, in accordance with article VII, section 2:

1) Amend article II, section 1, to read as follows: "Section 1. The officers of the Association shall consist of a President, a First Vice-President, a Second Vice-President, and a Secretary who shall also act as Treasurer. The President and the two Vice-Presidents shall be elected for two years, the Secretary for four years. In case of absence of the President and one or both Vice-Presidents, the members of the Executive Committee, in order of seniority, shall preside."

2) Amend article III, by striking out the word 'eleven' and inserting the word 'twelve' in the first sentence.

On motion, duly seconded, the foregoing amendments to the Constitution were adopted.

Election of Officers: Professor Clarence M. Jackson, Chairman of the Committee on Nominations for 1932, placed before the Association the following nominations for office:

For President, Professor George E. Coghill; for First Vice-President, Professor Benjamin F. Kingsbury; for Second Vice-President, Professor George W. Bartelmez; for members of the Executive Committee, Professor Robert S. Cunningham, of Vanderbilt University, and Professor Augustus G. Pohlman, of St. Louis University.

On motion, seconded and carried, the Secretary was instructed to cast a ballot for the election of the above-named, with terms of office as specified in the Constitution of the Association.

New Members: The Secretary presented the following names recommended by the Executive Committee for election to membership in the Association:

ALLEN, WILLARD M., A.B., M.A., *University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

BLOUNT, R. F., Ph.D., Instructor in Anatomy, *University of Minnesota, Minneapolis, Minn.*

CARPENTER, RUSSELL L., B.S., Ph.D., Associate in Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City*

FREUDENBERGER, CLAY B., Ph.D., Professor of Anatomy, *University of Utah, Salt Lake City, Utah.*

GRAFFLIN, ALLAN L., A.B., M.D., Instructor in Anatomy, *Harvard Medical School, Boston, Mass.*

HORNING, ERIC S., D.Sc., Assistant Professor of Anatomy, *University of Sydney, Sydney, Australia.*

- HUNT, THOMAS E., Ph.D., Assistant Professor of Anatomy, *University of Alabama Medical School, University, Ala.*
- KROGMAN, WILTON M., Ph.D., Associate Professor of Physical Anthropology, *Western Reserve University, Cleveland, Ohio.*
- MACEWEN, EWEN, M.D., Professor of Anatomy, *University of Iowa, Iowa City, Iowa.*
- RAWLINSON, HERBERT E., M.D., Instructor in Histology and Embryology, *McGill University, Montreal, Canada.*
- RIOCH, DAVID MCK., A.B., M.D., Assistant Professor of Anatomy, *Harvard Medical School, Boston, Mass.*
- SCHWIND, JOSEPH L., A.B., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical College, First Ave. and 28th St., New York City.*
- SHEININ, JOHN J., B.S., M.S., Department of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*
- SMITH, WILBUR K., A.B., M.D., Assistant Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*
- WEBB, RICHARD L., A.B., M.S., Ph.D., Associate in Anatomy, *College of Medicine, University of Illinois, 1817 West Polk St., Chicago, Ill.*
- WOLFE, JACK M., Ph.D., Instructor in Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*

On motion, duly seconded, the Secretary was instructed to cast a ballot for all candidates proposed by the Executive Committee.

Members Deceased: The Secretary then announced, on behalf of the Executive Committee, that the Association has suffered great loss in the death of the following active members:

WILLIAM KEILLER, Galveston, Texas. H. J. PRENTISS, Iowa City, Iowa.

Resignation of Members: The Secretary then announced, on behalf of the Executive Committee, the resignation of the following members:

HENRY A. MURRY, Cambridge, Massachusetts.

Y. G. NADGIR, Bombay, India.

ARTHUR ROBINSON, Edinburgh, Scotland.

Members Dropped: The Secretary then announced the following names dropped from the list of members on account of non-payment of dues for the past two years:

P. G. SNOW, Salt Lake City, Utah.

F. H. STALEY, St. Louis, Missouri.

W. L. WINKENWERDER, Baltimore, Maryland.

MINORU ARATAKI, Asahigawa, Japan.

SHINKISHI HATAI, Sendai, Japan.

E. E. REINKE, Nashville, Tennessee.

Representatives of Association: The Secretary then presented for consideration, on behalf of the Executive Committee, the following resolution:

Be it ordered by the Association that:

1. The Executive Committee shall nominate each year, for election by the Association at the Annual Meeting, two members to serve as representatives to the Council of the American Association for the Advancement of Science at the meetings of the Council during the same year.

2. The Executive Committee shall nominate from time to time, for election by the Association, one member to serve as representative to the Union of Biological Societies, and one as representative to the National Research Council; their terms of office to be three years.

3. The Executive Committee shall nominate each year, for election by the Association, one member to serve as representative on the Committee for Standardization of Biological Stains, the same person to be reappointed from year to year as the Association sees fit.

This order was adopted by vote of the Association.

Report of Special Committee: Professor Arey, Chairman of the committee appointed at the forty-seventh meeting to consider a proposal to institute a form of associate membership, presented a report discussing the proposal. After general discussion it was voted to lay the report on the table.

Dues for the year 1932: A recommendation of the Executive Committee, that the dues for the year 1932 be set at one dollar per member, was adopted by the Association.

Payment to Local Committee: In accordance with the policy adopted by the Association at the forty-third session, it was moved, seconded, and voted that the Treasurer be authorized to pay the sum of \$150.00 from the general funds of the Association to the Local Committee on Arrangements at Columbia University, College of Physicians and Surgeons, for the purpose of defraying the cost of entertainment of the Association during the present forty-eighth session.

Brachet Memorial Fund: A letter from Professor Gérard, of Brussels, announcing the establishment of a fund to create a memorial to the late Professor Brachet, to which his American friends are welcome to contribute, was laid before the members.

Place of Next Meeting: It was announced that the Executive Committee had decided to hold the forty-ninth session of the Association at the University of Cincinnati on the three days immediately preceding Easter, 1933 (April 13, 14, 15).

New Business: Professor William H. F. Addison presented the following resolution:

The members of the American Association of Anatomists, assembled in New York at their Forty-eighth annual Session, wish to extend their sincere felicitations to Professor Santiago Ramón y Cajal on his eightieth birthday (May 1, 1932), and to express their great appreciation of his invaluable achievements in the field of neuro-histology, and of the ever-widening influence of his investigations and methods of research on the anatomical sciences.

On motion, the resolution was unanimously adopted, and the Secretary was directed to transmit it to Professor Cajal.

Honorary Members: After a general discussion as to the advisability of electing distinguished foreign anatomists to honorary membership in the Association (the list of honorary members being at present reduced to two) it was voted to submit the question to the Executive Committee as a special order of business for consideration at the forty-ninth meeting.

On motion, the Business Session then adjourned.

SATURDAY, MARCH 26, 1932

12 noon. Concluding business session. A short business meeting followed the morning scientific sessions. The Secretary reported that the Executive Committee, in accordance with the order adopted on the previous day, proposed the following nominations: Representative to the Union of Biological Societies, Professor H. H. Donaldson; Representative on the Committee on Standardization of Biological Stains, Professor H. E. Jordan; Representatives on the Council of the American Association for the Advancement of Science, Professors Eliot R. Clark and George W. Corner.

The persons proposed were elected.

Nomination of a representative to the Medical Division of the National Research Council was not made at this time, since the present representative was elected in 1930 for a three-year term.

Resolution of Sympathy: Word having been received of the death, on March 24th, of Professor Frederic W. Thyng, long a valued member of the Association, Professor H. D. Senior was requested to prepare a resolution expressing the regret of the members and our sympathy with his family. The resolution was unanimously adopted. It has been forwarded to Mrs. Thyng, and a copy is filed in the records of the Association.

Resolution of Appreciation: Professor H. H. Donaldson presented the following resolution:

To the authorities of the College of Physicians and Surgeons of Columbia University, to the local committee, and especially to its energetic chairman, the members of the American Association of Anatomists present their cordial thanks for arranging with skill and imagination to care for their scientific needs and social welfare both at work and at play. Those who thus express their appreciation do so with ample knowledge of the forethought needed to achieve a success such as marks the present meeting—held though it is amid the baronial halls of the towering Medical Center.

Moved, seconded, and unanimously voted.

On motion, the Session adjourned.

GEORGE W. CORNER,

Secretary of the Forty-eighth Session of
the American Association of Anatomists.

AMERICAN ASSOCIATION OF ANATOMISTS

CONSTITUTION

ARTICLE I

Section 1. The name of the society shall be "The American Association of Anatomists."

Sec. 2. The purpose of the Association shall be the advancement of anatomical science.

ARTICLE II

Section 1. The officers of the Association shall consist of a President, a First Vice-President, a Second Vice-President, and a Secretary who shall also act as Treasurer. The President and the two Vice-Presidents shall be elected for two years, the Secretary for four years. In case of absence of the President and one or both Vice-Presidents, the members of the Executive Committee, in order of seniority, shall preside. The election of all the officers shall be by ballot at the annual meeting of the Association and their official term shall commence with the close of the annual meeting.

Sec. 2. At the annual meeting next preceding an election, the President shall name a nominating committee of three members. This committee shall make its nominations to the Secretary not less than two months before the annual meeting at which the election is to take place. It shall be the duty of the Secretary to mail the list to all members of the Association at least one month before the annual meeting. Additional names for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

ARTICLE III

The management of the affairs of the Association shall be delegated to an Executive Committee, consisting of twelve members, including the officers. Two members of the Executive Committee shall be elected annually, and, so far as possible, election of members of the Executive Committee shall be in proportion to the geographical distribution of members. Five shall constitute a quorum of the Executive Committee.

ARTICLE IV

The Association shall meet at least annually, the time and place to be determined by the Executive Committee. The annual meeting for the election of officers shall be the meeting of convocation week, or in case this is not held, the first meeting after the new year.

ARTICLE V

Section 1. Candidates for membership must be persons engaged in the investigation of anatomical or cognate sciences, and shall be proposed in writing to the Executive Committee by two members, who shall accompany the recommendation by a list of the candidate's publications, together with references. Their election by the Executive Committee, to be effective, shall be ratified by the Association in open meeting.

Sec. 2. Honorary members may be elected from those who have distinguished themselves in anatomical research. Nominations by the Executive Committee must be unanimous and their proposal with a reason for recommendations shall be presented to the Association at an annual meeting, a three-fourths vote of members present being necessary for an election.

ARTICLE VI

The annual dues of the Association shall be determined at each annual meeting for the ensuing year. A member in arrears for dues for two years shall be dropped by the Secretary at the next meeting of the Association, but may be reinstated at the discretion of the Executive Committee on payment of arrears.

ARTICLE VII

Section 1. Twenty members shall constitute a quorum for the transaction of business.

Sec. 2. Any change in the constitution of the Association must be presented in writing at one annual meeting in order to receive consideration and be acted upon at the next annual meeting; due notice of the proposed change to be sent to each member at least one month in advance of the meeting at which such action is to be taken.

Sec. 3. The ruling of the Chairman shall be in accordance with "Robert's Rules of Order."

ORDERS

The following orders adopted by this Association have not been altered:

Newly elected members must qualify by payment of dues for one year within thirty days after election.

The maximum limit of time for the reading of papers shall be twelve minutes.

The Secretary and Treasurer shall be allowed his traveling expenses and the sum of \$10 toward the payment of his hotel bill, at each session of the Association.

The Executive Committee shall nominate each year, for election by the Association at the Annual Meeting, two members to serve as representatives to the Council of the American Association for the Advancement of Science at the meetings of the Council during the same year.

The Executive Committee shall nominate from time to time, for election by the Association, one member to serve as representative to the Union of Biological Societies, and one as representative to the National Research Council; their terms of office to be three years.

The Executive Committee shall nominate each year, for election by the Association, one member to serve as representative on the Committee for Standardization of Biological Stains, the same person to be reappointed from year to year as the Association sees fit.

AMERICAN ASSOCIATION OF ANATOMISTS

OFFICERS AND LIST OF MEMBERS

Officers

<i>President</i>	GEORGE E. COGHILL
<i>First Vice-President</i>	BENJAMIN F. KINGSBURY
<i>Second Vice-President</i>	GEORGE W. BARTELMEZ
<i>Secretary-Treasurer</i>	GEORGE W. CORNER

Executive Committee

For term expiring 1933.....	HAROLD S. BURR, CARL G. HARTMAN
For term expiring 1934.....	LESLIE B. AREY, SAMUEL R. DETWILER
For term expiring 1935.....	PAUL I. MCKIBBEN, EDWARD F. MALONE
For term expiring 1936.....	ROBERT S. CUNNINGHAM, AUGUSTUS G. POHLMAN

Delegates to the Council of A. A. A. S. for 1932

ELIOT R. CLARK
GEORGE W. CORNER

Representative to the National Research Council, 1930-1933

J. PARSONS SCHAEFFER

Representative on the Commission on Standardization of Biological Stains

HARVEY E. JORDAN

Delegate to Union of Biological Societies, 1932-1935

HENRY H. DONALDSON

Committee on Nominations for 1933

RICHARD E. SCAMMON, *Chairman*
STACY R. GUILD GEORGE B. WISLOCKI

HONORARY MEMBERS

S. RAMÓN Y CAJAL.....	Madrid, Spain
A. NICHOLAS.....	Paris, France

MEMBERS

- ABBOTT, MAUDE E., B.A., C.M., M.D., L.R.C.P. & S. (Edin.), F.R.C.P. (Canada), Assistant Professor of Research Medicine and Curator of Medical Museum, McGill University, 3640 University St., Montreal, Canada.
- ABERLE (Mrs.), SOPHIE B. D., A.B., A.M., Ph.D., M.D., Instructor Obstetrics and Gynecology, Yale University, School of Medicine, New Haven, Conn.
- ADAMS, A. ELIZABETH, A.B., A.M., Ph.D., Professor of Zoölogy, Mount Holyoke College, South Hadley, Mass.
- ADAMS, L. A., A.B., A.M., Ph.D., Assistant Professor of Zoölogy, University of Illinois, 207 Iowa St., Urbana, Ill.
- ADDISON, WILLIAM HENRY FITZGERALD, B.A., M.D., Professor of Normal Histology and Embryology, School of Medicine, University of Pennsylvania, Philadelphia, Penna.
- ADELMANN, HOWARD B., B.A., M.A., Ph.D., Assistant Professor of Histology and Embryology, Cornell University, Stimson Hall, Ithaca, N. Y.
- ALLEN, BENNET MILLS, Ph.D., Professor of Zoölogy, University of California (Southern Branch), 909 Micheltorena St., Los Angeles, Calif.
- ALLEN, EDGAR, A.M., Ph.D. (Vice-Pres. '30-'32), Professor of Anatomy and Dean of the School of Medicine, University of Missouri, Columbia, Mo.
- ALLEN, EZRA, A.M., Ph.D., Associate Editor, Biological Abstracts; Associate Professor of Histology and Embryology, New York Homeopathic Medical School, York Ave. and Sixty-fourth St., New York City.
- ALLEN, WILLARD M., A.B., M.A., University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.
- ALLEN, WILLIAM F., A.M., Ph.D., Professor of Anatomy, University of Oregon Medical School, Portland, Oregon.
- ALLIS, EDWARD PHELPS, JR., C.E., M.D., LL.D., Palais de Carnoles, Menton (A.M.), France.
- ANDERSEN, DOROTHY H., M.D., Instructor in Pathology, Columbia University, 630 West 168th Street, New York City.
- ANGULO Y GONZÁLEZ, ARMANDO W., A.B., B.S., A.M., Ph.D., Associate Member, The Wistar Institute of Anatomy, 36th Street and Woodland Ave., Philadelphia, Pa.
- ANSON, BARRY J., A.B., A.M., Ph.D., Associate Professor of Anatomy, Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.
- APPLEBY, J. I., A.B., M.B., A.M., M.D., Physician and Surgeon, Company Surgeon, N. Y. C. & St. L. R. R. Co., 105½ East Main St., Bellevue, Ohio.
- AREY, LESLIE B., Ph.D. (Ex. Com. '30-), Robert Laughlin Rea Professor of Anatomy, and Chairman of the Division of Anatomy, Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.
- ARMSTRONG, PHILIP BROWNELL, B.S., M.D., Assistant Professor of Anatomy, Cornell University Medical College, 477 First Ave., New York City.
- ASDELL, SYDNEY ARTHUR, Ph.D., Assistant Professor in Charge of Physiology of Reproduction, State College of Agriculture, Cornell University, Ithaca, N. Y.
- ATTERBURY, RUTH RAND, A.M., Ph.D., 144 Overlook Ave., Great Neck, L. I.

- ATWELL, WAYNE JASON, A.M., Ph.D., Professor of Anatomy, University of Buffalo School of Medicine, *24 High St., Buffalo, N. Y.*
- BADERTSCHER, JACOB A., Ph.D., Professor of Anatomy, Indiana University School of Medicine, *312 South Fess Ave., Bloomington, Ind.*
- BAGLEY, CHARLES, JR., M.D., Assoc. Experimental Neurology, *The Latrobe Apts., Baltimore, Md.*
- BAILEY, PERCIVAL, M.D., Ph.D., Professor of Surgery, *University of Chicago, 950 East Fifty-ninth St., Chicago, Ill.*
- BAITSELL, GEORGE ALFRED, B.S., M.A., Ph.D., Professor of Biology, Yale University, *Osborn Zoölogical Laboratory, New Haven, Conn.*
- BAKER, R. C., A.B., M.A., Ph.D., Associate Professor of Anatomy, *Department of Anatomy, Hamilton Hall, Ohio State University, Columbus, Ohio.*
- BALDWIN, WESLEY MANNING, A.B., A.M., M.D., Professor of Anatomy, *Albany Medical College, Albany, N. Y.*
- BARDEEN, CHARLES RUSSELL, A.B., M.D. (Ex. Com. '06-'09, Vice-President '18-'20), Professor of Anatomy and Dean of Medical School, *University of Wisconsin, Science Hall, Madison, Wis.*
- BARTA, EDMUND, M.D., Adjunct, Department of Anatomy, *Royal University Medical School, Budapest, Hungary.*
- BARTELMIZ, GEORGE W., Ph.D., Professor of Anatomy, *University of Chicago, Chicago, Ill.*
- BARTSCH, PAUL, B.S., M.S., Ph.D., Curator of Mollusks and Cenozoic Invertebrates, *U. S. National Museum, Washington, D. C.*
- BASCOM, KELLOGG F., B.A., M.S., Ph.D., M.D., Assistant in Surgery, *Northwest Clinic, Minot, N. D.*
- BAST, T. H., B.A., Ph.D., Associate Professor of Anatomy, *University of Wisconsin, 308 Science Hall, Madison, Wis.*
- BATSON, O. V., A.M., M.D., Professor of Anatomy, *Department of Anatomy, Graduate School of Medicine, University of Pennsylvania, Philadelphia, Pa.*
- BAUMGARTNER, WILLIAM J., A.B., A.M., Ph.D., Professor of Zoölogy, University of Kansas, *1209 Ohio St., Lawrence, Kans.*
- BEAN, ROBERT BENNETT, B.S., M.D., Professor of Anatomy, University of Virginia, *5 Wayside Place, University, Va.*
- BEATTIE, JOHN, M.D., D.Sc., Associate Professor of Anatomy, *McGill University, Montreal, Canada.*
- BEGG, ALEXANDER S., B.S., M.D., Waterhouse Professor of Anatomy and Dean, Boston University School of Medicine, *80 East Concord St., Boston, Mass.*
- BENSLEY, ROBERT RUSSELL, A.B., M.B., Sc.D. (Second Vice-Pres. '06-'07, Ex. Com. '08-'12, President '18-'20), Professor of Anatomy, Director of Hull Laboratory of Anatomy, *University of Chicago, Chicago, Ill.*
- BEST, R. RUSSELL, B.Sc., M.D., Assistant Professor of Anatomy, Instructor in Surgery, Department of Anatomy, University of Nebraska, College of Medicine, *1218 Medical Arts Building, Omaha, Nebraska.*
- BEVAN, ARTHUR DEAN, M.D. (Ex. Com. '96-'98), Professor of Surgery, University of Chicago, *122 South Michigan Blvd., Chicago, Ill.*
- BIGELOW, ROBERT P., S.B., Ph.D., Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Cambridge A, Mass.*
- BISHOP, KATHERINE SCOTT, A.B., M.D., *1508 La Loma Ave., Berkeley, Calif.*

- BLACK, DAVIDSON, M.A., M.D., Professor of Anatomy, Peking Union Medical College, and Hon. Director, Cenozoic Laboratory, Geological Survey of China, *P. U. M. C., Peiping, China.*
- BLAIR, VILRAY PAPIN, A.M., M.D., Professor of Clinical Surgery, Washington University School of Medicine, *Metropolitan Building, St. Louis, Mo.*
- BLAISDELL, FRANK ELLSWORTH, SR., M.D., Emeritus Professor of Surgery, Medical Department of Stanford University, *Lane Medical Library Building, corner Webster and Sacramento Sts., San Francisco, Calif.*
- BLAKE, J. A., A.B., Ph.B., M.A., M.D., F.A.C.S., *Agua Caliente Ranch, Tucson, Arizona.*
- BLINCOE, HOMER, A.B., M.S., M.D., Professor of Gross Anatomy, *Emory University, Emory, Georgia.*
- BLOOM, WILLIAM, A.B., M.D., Assistant Professor of Anatomy, *Department of Anatomy, University of Chicago, Chicago, Ill.*
- BLOUNT, R. F., Ph.D., Instructor in Anatomy, *University of Minnesota, Minneapolis, Minn.*
- VON BONIN, GERHARDT, M.D., Associate in Anatomy, University of Illinois, College of Medicine, *1853 West Polk St., Chicago, Ill.*
- BOYD, EDITH, M.D., Assistant Professor, *Institute of Child Welfare, University of Minnesota, Minneapolis, Minn.*
- BOYDEN, EDWARD ALLEN, A.M., Ph.D. (Ex. Com. '28-'32), Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*
- BREMER, JOHN LEWIS, A.B., M.D. (Ex. Com. '15-'18), Hersey Professor of Anatomy, *Harvard Medical School, Boston, Mass.*
- BREMER, JOHN LEWIS, A.B., M.D. (Ex. Com. '15-'18), Associate Professor of Histology, *Harvard Medical School, Boston, Mass.*
- BROWNING, WILLIAM, Ph.B., M.D., Emeritus Professor of Neurology, Long Island College of Medicine, *54 Lefferts Place, Brooklyn, N. Y.*
- BRYCE, THOMAS H., M.A., M.D., F.R.S., Professor of Anatomy, University of Glasgow, *No. 2, The University, Glasgow, Scotland.*
- BULLARD, H. HAYS, A.M., Ph.D., M.D., *St. Vincent's Hospital, Erie, Pa.*
- BUNTING, CHARLES HENRY, B.S., M.D., Professor of Pathology, *University of Wisconsin, Service Memorial Institute, Madison, Wis.*
- BURNS, B. I., A.B., A.M., M.D., Dean and Professor of Anatomy, *University of Utah, School of Medicine, Salt Lake City, Utah.*
- BURNS, ROBERT K., JR., A.B., Ph.D., Associate Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*
- BURRE, HAROLD SAXTON, Ph.D., Professor of Anatomy, School of Medicine, Yale University, *333 Cedar St., New Haven, Conn.*
- BURROWS, MONTROSE T., A.B., M.D., Physician and Surgeon, Chairman Cancer Clinic, Pasadena Hospital, Consultant Pathologist Los Angeles County General Hospital, *94 North Madison Ave., Pasadena, Calif.*
- BUTCHER, EARL O., A.M., Ph.D., Associate Professor of Biology, *Hamilton College, Griffin Road, College Hill, Clinton, N. Y.*
- BUTLER, ELMER G., A.B., Ph.D., Associate Professor of Biology, *Laboratory of Comparative Anatomy, Princeton University, Princeton, N. J.*
- CALKINS, LEROY A., M.S., M.D., Ph.D., Professor of Obstetrics and Gynecology, *University of Kansas Hospital, Kansas City, Kan.*

- CAMERON, ANGUS L., A.B., M.S., M.D., Ph.D., *Northwest Clinic, Minot, N. Dak.*
- CARDWELL, JOHN C., M.D., Professor of Physiology, Long Island College of Medicine, Science Laboratory, 112 Pacific St., Brooklyn, N. Y.
- CAREY, EBEN J., M.S., Sc.D., M.D., Professor of Anatomy and Director of Anatomy Department, Marquette University School of Medicine, 1848 North Fourth Street, Milwaukee, Wis.
- CARPENTER, RUSSELL L., B.S., Ph.D., Associate in Anatomy, College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.
- CARVER, GAIL L., A.B., A.M., Professor of Biology, Mercer University, 613 Orange St., Macon, Ga.
- CASAMAJOR, LOUIS, A.M., M.D., Professor of Neurology, Columbia University, 630 West 168th St., New York City.
- CHAMBERS, ROBERT, JR., A.M., Ph.D., Research Professor of Biology and Chairman of the Department of Biology, Washington Square College, New York University, New York City.
- CHANG, CHUN, M.D., Associate Professor of Anatomy, National Central University, College of Medicine, Woosung, Shanghai, China.
- CHARIPPER, HARRY A., B.S., M.S., Ph.D., Assistant Professor of Comparative Anatomy, Embryology, and Histology, Washington Square College, New York University, New York City.
- CHARLES, CECIL M., A.B., M.A., Ph.D., Assistant, Department of Anatomy, Washington University School of Medicine, St. Louis, Mo.
- CHARLTON, HARRY HAYWARD, A.B., A.M., Ph.D., Professor of Anatomy, Department of Anatomy, University of Missouri, Columbia, Mo.
- CHASE, SAMUEL WOOD, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.
- CHIDESTER, FLOYD E., A.M., Ph.D., Professor of Zoölogy, University of West Virginia, Morgantown, W. Va.
- CHILD, CHARLES MANNING, M.S., Ph.D., Professor of Zoölogy, Zoölogical Laboratory, University of Chicago, Chicago, Ill.
- CHILLINGWORTH, FELIX P., M.D., Professor of Experimental Pharmacology, Tufts Medical College, 416 Huntington Ave., Boston, Mass.
- CHOUKE, KEHAR SINGH, M.A., M.D., Assistant Professor of Anatomy, Colorado University Medical School, 4200 East Ninth Ave., Denver, Colo.
- CLARK, ELEANOR LINTON, A.M., Voluntary Research Worker, Department of Anatomy, Medical Department, University of Pennsylvania, Philadelphia, Pa.
- CLARK, ELIOT R., A.B., M.D. (Ex. Com. '16-'19), Professor of Anatomy and Director of Department of Anatomy, University of Pennsylvania, 301 St. Mark's Square, Philadelphia, Pa.
- CLARK, SAM L., M.S., Ph.D., M.D., Associate Professor of Anatomy, Vanderbilt University School of Medicine, Nashville, Tenn.
- COE, WESLEY R., Ph.D., Professor of Biology, Yale University, Osborn Zoölogical Laboratory, New Haven, Conn.
- COGHILL, GEORGE E., A.B., M.S., Ph.D., Sc.D. (Ex. Com. '27-'31, Pres. '32-), Member of The Wistar Institute of Anatomy and Biology, 36th Street and Woodland Ave., Philadelphia, Pa.
- COHN, ALFRED E., A.B., M.D., Member, Rockefeller Institute for Medical Research, New York City, N. Y.

- COLE, ARCH EVAN, A.B., Ph.D., Assistant Professor, Anatomy Department, *University of Louisville, Louisville, Kentucky.*
- COLE, HAROLD H., Ph.D., Assistant Professor of Animal Husbandry, University of California, and Assistant Animal Husbandman, *Experiment Station of the College of Agriculture, Davis, Calif.*
- COLLINS, HENRY HOMER, Ph.D., Professor of Zoölogy, *University of Pittsburgh, Pittsburgh, Pa.*
- COMAN, FRANCIS DANA, A.B., A.M., M.D., Assistant in Surgery, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*
- CONANT, WILLIAM MERRITT, A.B., M.D., Surgeon, *636 Beacon St., Boston, Mass.*
- CONEL, JESSE LEROY, A.M., Ph.D., Professor of Anatomy, Boston University School of Medicine, *80 E. Concord St., Boston, Mass.*
- CONGDON, EDGAR DAVIDSON, Ph.D., *Alger Court, Pondfield Rd., Bronxville, N. Y.*
- CONKLIN, EDWIN GRANT, A.M., Ph.D., Sc.D., LL.D., Professor of Biology, Princeton University, *139 Broadmead Ave., Princeton, N. J.*
- COPENHAVER, WILFRED M., A.B., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*
- COREY, EDWARD LYMAN, A.B., Ph.D., Assistant Professor of Physiology, *University of Virginia, Charlottesville, Virginia.*
- CORNER, GEORGE W., A.B., M.D. (Ex. Com. '26-'30; Sec.-Treas. '30-), Professor of Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*
- CORNING, H. K., M.D., Professor of Anatomy, *University of Bâle, Anatomische Anstalt, Bâle, Switzerland.*
- COVELL, W. P., M.S., Ph.D., Assistant, *Washington University School of Medicine, St. Louis, Mo.*
- COWDRY, EDMUND V., Ph.D. (Ex. Com. '26-'30), Professor of Cytology, *Washington University Medical School, St. Louis, Missouri.*
- CRAIGIE, E. HORNE, B.A., Ph.D., Assistant Professor of Comparative Anatomy and Neurology, *Department of Biology, University of Toronto, Toronto, 5, Canada.*
- CRILE, GEORGE W., M.D., F.A.C.S., Professor Emeritus of Surgery, Western Reserve University, *Cleveland Clinic, 93rd and Euclid, Cleveland, Ohio.*
- CROSBY, ELIZABETH CAROLINE, M.S., Ph.D., Associate Professor of Anatomy, University of Michigan, *201 N. Thayer St., Ann Arbor, Mich.*
- CUAJUNCO, FIDEL, M.D., Assistant Professor of Anatomy, College of Medicine, University of the Philippines, *620 Colorado St., Manila, P. I.*
- CULLEN, THOMAS S., M.B., D.Sc., LL.D. (Tor.), Professor of Clinical Gynecology, Johns Hopkins University, Gynecologist to the Johns Hopkins Hospital, *20 E. Eager St., Baltimore, Md.*
- CUMMINS, HAROLD, A.B., Ph.D., Associate Professor of Anatomy, *Tulane University Medical School, Department of Anatomy, Sta. 20, New Orleans, La.*
- CUNNINGHAM, ROBERT S., B.S., A.M., M.D. (Ex. Com. '32-), Professor of Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*
- CURTIS, GEORGE M., A.M., Ph.D., M.D., Associate Professor of Surgery, *Billings Memorial Hospital, University of Chicago, Chicago, Ill.*
- DAHLGREN, ULRIC, A.B., M.S., Professor of Biology, Princeton University, *204 Guyot Hall, Princeton, N. J.*
- DANFORTH, CHARLES HASKELL, A.M., Ph.D. (Ex. Com. '27-'31), Professor of Anatomy, Stanford University, *607 Cabrillo Ave., Stanford University, Calif.*

- DARRACH, WILLIAM, A.B., A.M., M.D., Sc.D., LL.D., Professor of Clinical Surgery and Dean Emeritus of Faculty of Medicine, College of Physicians and Surgeons, Columbia University, 180 Fort Washington Ave., New York City.
- DART, RAYMOND A., M.D., Ch.M., M.Sc., Professor of Anatomy and Dean of Faculty of Medicine, University of the Witwatersrand, Johannesburg, Transvaal, South Africa.
- DAVENPORT, H. A., M.D., Assistant Professor of Anatomy, Northwestern University Medical School, Chicago, Illinois.
- DAVIS, CARL L., M.D., Professor of Anatomy, University of Maryland School of Medicine, Lombard and Greene Streets, Baltimore, Md.
- DAVIS, WARREN B., M.D., F.A.C.S., Associate in Surgery and Chief Maxillo-Facial Clinic, Jefferson Hospital; Consulting Maxillo-Facial Surgeon, Kensington Hospital; Otolaryngologist, St. Agnes Hospital; Assistant Surgeon, Frankford Hospital; 135 South 18th Street, Philadelphia, Pa.
- DAWSON, ALDEN B., A.B., Ph.D., Associate Professor of Zoölogy, Zoölogical Laboratory, Institute of Biology, Harvard University, Cambridge, Mass.
- DE CARLO, JOHN, M.D., Associate in Topographic and Applied Anatomy, Jefferson Medical College, 1629 S. Broad St., Philadelphia, Pa.
- DE GARIS, CHARLES F., A.B., M.D., Ph.D., Associate in Anatomy, Johns Hopkins Medical School, Baltimore, Md.
- DETWILER, SAMUEL RANDALL, Ph.B., A.M., Ph.D., M.S. (Hon.) (Ex. Com. '30-), Professor of Anatomy, Department of Anatomy, College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.
- DIXON, A. FRANCIS, M.B., Sc.D., University Professor of Anatomy, Trinity College, 42 Elgin Road, Dublin, Ireland.
- DOAN, CHARLES A., B.S., M.D., Director, Department of Medical and Surgical Research, Ohio State University, Hamilton Hall, Columbus, Ohio.
- DODDS, GIDEON S., A.M., Ph.D., Professor of Histology and Embryology, West Virginia University Medical School, Morgantown, W. Va.
- DODSON, JOHN MILTON, A.M., M.D., Professor (Emeritus) of Medicine, Rush Medical College, 535 N. Dearborn St., Chicago, Ill.
- DONALDSON, HENRY HERBERT, Ph.D., D.Sc. (Ex. Com. '09-'13, Pres. '16-'17), Member of The Wistar Institute, The Wistar Institute of Anatomy and Biology, Woodland Ave. and Thirty-sixth St., Philadelphia, Pa.
- DONALDSON, JOHN C., Ph.B., M.D., Professor of Anatomy, School of Medicine, University of Pittsburgh, Pittsburgh, Pa.
- DOWNEY, HAL, A.M., Ph.D., Professor of Anatomy, University of Minnesota Medical School, Minneapolis, Minn.
- DOWNES, WILLIAM GERSHOM, JR., A.B., A.M., D.D.S., Ph.D., 415 S.E. 2nd St., Evansville, Ind.
- DUESBERG, JULES, M.D., Professor of Anatomy, University of Liege, 22 quai Mative, Liege, Belgium.
- DUNCAN, DONALD, A.B., A.M., Ph.D., Assistant Professor of Anatomy, University of Buffalo, 24 High Street, Buffalo, N. Y.
- DUNN, H. L., B.A., M.A., M.B., Ph.D., M.D., Head of Department of Medical Statistics, Mayo Clinic, Rochester, Minnesota.
- ECCLES, ROBERT G., M.D., Phar.D., 681 Tenth St., Brooklyn, N. Y.

- EDWARDS, J. GRAHAM, M.A., Ph.D., Assistant Professor of Anatomy, University of Buffalo School of Medicine, *24 High Street, Buffalo, N. Y.*
- EDWARDS, LINDEN F., Assistant Professor of Anatomy, Ohio State University College of Medicine, *Hamilton Hall, Columbus, Ohio.*
- ELWYN, ADOLPH, A.M., Assistant Professor of Neurology, *Columbia University, 630 West 168th St., New York City.*
- ENGLE, EARL THERON, A.B., A.M., Ph.D., Associate Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*
- ESAKI, SHIRO, Assistant Professor of Anatomy, *Keio-Gigyaku University, Yotsuya, Tokyo, Japan.*
- ESSICK, CHARLES RHEIN, B.A., M.D., *439 Oley St., Reading, Pa.*
- EVANS, HERBERT MCLEAN, B.S., M.D. (Ex. Com. '19-'22; Pres. '30-'32), Hertzstein Professor of Biology, Professor of Anatomy, Chairman of Department of Anatomy, and Director of Institute of Experimental Biology, *University of California, Berkeley, Calif.*
- EVANS, THOMAS HORACE, M.D., Associate Professor of Anatomy, Long Island College Hospital, *Room 83, Polhemus Memorial, 350 Henry St., Brooklyn, N. Y.*
- FARIS, HERVEY S., A.B., A.M., Ph.D., M.D., Practicing Physician and Surgeon, *3616 Main St., Riverside, Calif.*
- FERRIS, HARRY BURR, A.B., M.D., E. K. Hunt Professor of Anatomy, Medical Department, Yale University, *395 St. Ronan St., New Haven, Conn.*
- FETTEROLF, GEORGE, A.B., M.D., Sc.D., Professor of Oto-laryngology, University of Pennsylvania, *2010 Spruce St., Philadelphia, Pa.*
- FISCHELIS, PHILIPP, M.D., Professor of Histology, Embryology, and General Pathology, Philadelphia Dental College of Temple University, *2132 N. 19th St., Philadelphia, Pa.*
- FLEXNER, LOUIS BARKHOUSE, S.B., M.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- FLORENCE, LAURA, B.Sc., M.A., Ph.D., Associate Professor of Bacteriology, *New York Homeopathic Medical College, 445 E. Sixty-fifth St., New York City.*
- FOLEY, JAMES OWEN, M.S., Ph.D., Assistant Professor of Anatomy, *University of Alabama School of Medicine, University, Ala.*
- FORMAN, JONATHAN, A.B., M.D., Director of Pathological Laboratories, Grant Hospital, *394 East Town St., Columbus, Ohio.*
- FRASSETTO, FABIO, Sc.D., M.D., Director Anthropological Institute, *University of Bologna, Bologna, Italy.*
- FRASER, DORIS A., Ph.D., Assistant in Anatomy, *University of Pennsylvania School of Medicine, Philadelphia, Pa.*
- FRAZER, JOHN ERNEST, M.D., F.R.C.S., Professor of Anatomy, University of London, *St. Mary's Hospital Medical School, London, W., England.*
- FRENCH, H. E., M.S., M.D., Professor of Anatomy and Dean of the School of Medicine, *University of North Dakota, Grand Forks, North Dakota.*
- FREUDENBERGER, CLAY B., Ph.D., Professor of Anatomy, *University of Utah, Salt Lake City, Utah.*
- GAGE, SIMON HENRY, B.S. (Ex. Com. '06-'11), Professor of Histology and Embryology, Emeritus, *Stimson Hall, Cornell University, Ithaca, N. Y.*

- GALLAUDET, BERN BUDD, A.B., A.M., M.D., Associate Professor of Anatomy, Columbia University, Consulting Surgeon, Bellevue Hospital, 601 West 168th St., New York City.
- GAMBLE, DEAN L., B.S., Ph.D., President, Ward's Natural Science Establishment, 302 North Goodman St., Rochester, N. Y.
- GARCIA, ARTURO, A.B., M.D., Professor of Anatomy and Head of Department, College of Medicine, University of the Philippines, 619 Colorado St., Manila, Philippine Islands.
- GEIST, FREDERICK D., M.D., Assistant Professor of Anatomy, University of Wisconsin, Science Hall, Madison, Wis.
- GEORGE, RUGGLES KERR, B.A., M.B., D.P.H., Special Lecturer in Anatomy, University of Toronto, Toronto 5, Canada.
- GEORGE, WESLEY CRITZ, A.B., A.M., Ph.D., Professor of Histology and Embryology, University of North Carolina Medical School, Chapel Hill, N. C.
- GILLASPIE, C., M.D., F.A.C.S., Associate Professor of Anatomy, University of Colorado, Boulder, Colo.
- GLOBUS, J. H., B.S., M.D., Associate Professor of Neuro-anatomy and Neuro-pathology, New York University and Bellevue Medical College, 1185 Park Ave., New York City.
- GOSS, CHARLES MAYO, A.B., M.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.
- GOULD, HARLEY NATHAN, A.B., A.M., Ph.D., Professor of Biology, Newcomb College, Tulane University, New Orleans, La.
- GRAFFLIN, ALLAN L., A.B., M.D., Instructor in Anatomy, Harvard Medical School, Boston, Mass.
- GRANT, J. C. BOILEAU, M.B., Ch.B., F.R.C.S., Professor of Anatomy, University of Toronto, Toronto, Canada.
- GRAVES, WILLIAM W., M.D., Professor and Director, Department of Neuro-psychiatry, St. Louis University School of Medicine, St. Louis, Mo.
- GREENE, CHARLES W., A.M., Ph.D., Professor of Physiology and Pharmacology, University of Missouri, 814 Virginia Ave., Columbia, Mo.
- GREENE, WALTER FARRAR, A.B., Ph.D., Associate Professor of Anatomy, Syracuse College of Medicine, 309 South McBride St., Syracuse, N. Y.
- GREENHILL, J. P., B.S., M.D., F.A.C.S., Attending Obstetrician, The Chicago Lying-in-Hospital, Associate in Obstetrics, Northwestern University Medical School, Attending Gynecologist, Cook County Hospital, 185 N. Wabash Ave., Chicago, Ill.
- GREENMAN, MILTON J., Ph.B., M.D., Sc.D., Director of The Wistar Institute of Anatomy and Biology, 36th St. and Woodland Ave., Philadelphia, Pa.
- GREGORY, WILLIAM KING, A.B., A.M., Ph.D., Professor of Vertebrate Palaeontology, Columbia; Curator Departments of Comparative Anatomy and Ichthyology, Research Associate in Anthropology and Palaeontology, American Museum of Natural History, New York City.
- GRODINSKY, MANUEL, B.Sc., M.D., Assistant Professor of Anatomy, University of Nebraska, College of Medicine, 42nd and Dewey Ave., Omaha, Neb.
- GUDENRATSCH, F., Ph.D., Visiting Professor, Department of Biology, New York University, Washington Square East, New York City.

- GUILD, STACY R., A.M., Ph.D., Lecturer in Otology and Director of Otological Research Laboratory, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*
- GURDJIAN, ELISHA STEPHENS, A.B., M.S., M.D., Ph.D., Neuro-Surgeon, Receiving and Harper Hospitals, *840 David Whitney Bldg., Detroit, Mich.*
- GUTTMACHER, ALAN F., A.B., M.D., Clinical Instructor in Obstetrics, Johns Hopkins University, *824 Park Ave., Baltimore, Md.*
- GUYER, MICHAEL F., Ph.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*
- HALL, BYRON E., Teaching Fellow in Anatomy, *University of Minnesota Medical School, Minneapolis, Minn.*
- HALL, E. RAYMOND, Ph.D., Assistant Professor of Vertebrate Zoölogy, Curator of Mammals, *California Museum of Vertebrate Zoölogy, University of California, Berkeley, Calif.*
- HALPERT, BÉLA, M.D., Cushing Fellow in Surgery, Department of Surgery, *Yale University Medical School, New Haven, Conn.*
- HANAN, ERNEST B., A.B., A.M., M.D., Associate in Anatomy; Director of Laboratories of Buffalo City Hospital, *University of Buffalo, Buffalo, N. Y.*
- HANSON, FRANK BLAIR, A.B., A.M., Ph.D., Professor of Zoölogy, *Washington University, St. Louis, Mo.*
- HARDESTY, IRVING, A.B., Ph.D., Sc.D. (Ex. Com. '10 and '12-'15, '22-'23), Professor of Anatomy and Head of Department of Anatomy, School of Medicine, *Tulane University, P. O. Station 20, New Orleans, La.*
- HARE, EARL R., A.B., M.D., F.A.C.S., *730 LaSalle Building, Minneapolis, Minn.*
- HARGITT, GEORGE T., A.B., A.M., Ph.D., Professor of Zoölogy, *Duke University, Durham, N. C.*
- HARRIS, HENRY A., M.B., B.S., F.Z.S., M.R.C.S., L.R.C.P., D.Sc., Professor of Clinical Anatomy and Assistant to the Medical Unit, *Institute of Anatomy, University College and University College Hospital, Gower St., London, W.C.1, England.*
- HARRISON, ROSS GRANVILLE, Ph.D., M.D., Sc.D. (Pres. '12-'14), Sterling Professor of Biology and Director of Osborn Zoölogical Laboratory, *Yale University, New Haven, Conn.*
- HARTMAN, CARL G., Ph.D., Research Associate, *Carnegie Laboratory of Embryology, Johns Hopkins Medical School, Baltimore, Md.*
- HARVEY, BASIL COLEMAN HYATT, A.B., M.B., Professor of Anatomy and Dean of Students, Division of Biological Sciences, *University of Chicago, Chicago, Ill.*
- HARWELL, CHARLES W., A.B., M.D., Assistant Professor of Micro-anatomy, *Emory University, Emory, Ga.*
- HATT, ROBERT T., Sc.B., M.A., Assistant Curator, Department of Mammology, *American Museum of Natural History, New York City.*
- HAUSMAN, LOUIS, A.B., M.D., Associate in Neuro-anatomy, Cornell Medical School, *1175 Park Ave., New York City.*
- HAZEN, CHARLES MORSE, A.M., M.D., *Professional Building, Fifth and Franklin Sts., Richmond, Va.*
- HEINBECKER, PETER, M.D., Assistant Professor of Surgery, *Washington University Medical School, St. Louis, Missouri.*

- HEISLER, JOHN C., M.D., Emeritus Professor of Anatomy, University of Pennsylvania, 3829 Walnut St., Philadelphia, Pa.
- HELDT, THOMAS JOHANES, A.B., A.M., M.D., Physician in Charge of Neuropsychiatric Division, *Henry Ford Hospital, Detroit, Mich.*
- HELFF, O. M., B.S., M.S., Ph.D., Associate Professor of Biology, *New York University, New York City.*¹
- HERRICK, CHARLES JUDSON, Ph.D. (Ex. Com. '13-'17), Professor of Neurology, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*
- HERTZLER, ARTHUR E., B.S., A.M., Ph.D., M.D., LL.D., F.A.C.S., Professor of Surgery, *University of Kansas, Halstead, Kansas.*
- HETHERINGTON, DUNCAN CHARACTERIS, A.B., M.A., Ph.D., M.D., Associate Professor of Anatomy, *Duke University Medical School, Durham, N. C.*
- HEUSER, CHESTER H., A.M., Ph.D., Research Associate, Department of Embryology, *Carnegie Institution, Johns Hopkins Medical School, Baltimore, Md.*
- HEWSON, ADDINELL, A.B., A.M., M.D., F.A.C.S., Emeritus Professor of Anatomy, Graduate School of Medicine, University of Pennsylvania, and Professor of Anatomy and Histology, Temple University Dental School; Secretary Anatomical Board of the State of Pennsylvania, 257 South 16th Street, Philadelphia, Pa.
- HIGGINS, GEORGE M., A.M., Ph.D., Associate in Experimental Surgery, *University of Minnesota, Mayo Foundation, Rochester, Minn.*
- HILL, EBEN CLAYTON, A.B., M.D., Lecturer in Roentgenological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- HILL, JAMES PETER, D.Sc., F.R.S., Professor of Embryology, University of London, *University College, Gower St., London., W. C. 1, England.*
- HILTON, WILLIAM A., B.S., Ph.D., Professor of Zoölogy, Pomona College, Director *Laguna Marine Laboratory, Claremont, Calif.*
- HINES, MARION, A.B., Ph.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- HINSEY, JOSEPH C., M.S., Ph.D., Professor of Anatomy, Department of Anatomy, *Stanford University, Calif.*
- HIRSCH, CHRISTIAN G., M.D., Professor of Experimental Histology, *Zoölogical Laboratory, The University, Utrecht, Holland.*
- HOADLEY, LEIGH, A.B., Ph.D., Professor of Zoölogy, *Harvard University, Cambridge, Mass.*
- HOGG, IRA D., B.A., M.A., Ph.D., Assistant Professor of Anatomy, Department of Anatomy, University of Pittsburgh School of Medicine, 115 Peebles St., *Pittsburgh, Pa.*
- HOGUE, MARY J., Ph.D., Instructor in Histology, *University of Pennsylvania Medical School, Philadelphia, Pa.*
- HOLMGREN, NILS, D.S., Professor of Zoölogy, *University of Stockholm, Sweden.*
- HOLT, CAROLINE M., A.B., A.M., Ph.D., Associate Professor of Biology and Public Health, Simmons College, 130 Elgin St., *Newton Centre, Mass.*
- HOOKE, DAVENPORT, M.A., Ph.D. (Ex. Com. '22-'25), Professor of Anatomy, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

- HOPKINS, GRANT SHERMAN, Sc.D., D.V.M., Professor Comparative Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*
- HORNING, ERIC S., D.Sc., Assistant Professor of Anatomy, *University of Sydney, Sydney, Australia.*
- HOSKINS, MARGARET MORRIS, Ph.D., Associate Professor of Microscopic Anatomy, *New York University Dental College, 209 East Twenty-third St., New York City.*
- HOWELL, A. BRAZIER, A.B., Lecturer in Comparative Anatomy, *Department of Anatomy, Johns Hopkins Medical School, Baltimore, Md.*
- HOWLAND, RUTH B., Ph.D., Associate Professor of Biology, *Washington Square College, New York University, Washington Square East, New York City.*
- HOY, WM. E., JR., A.B., Ph.D., Professor of Biology and Head of the Department of Biology, *University of South Carolina, 2318 Wheat St., Columbia, S. C.*
- HRDLÍČKA, ALEŠ, M.D., Sc.D., Curator, Division of Physical Anthropology, *United States National Museum, Smithsonian Institution, Washington, D. C.*
- HUBER, ERNST, Ph.D., M.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- HUBER, G. CARL, M.D., Sc.D. (Second Vice-Pres. '00-'01, Secretary-Treasurer '02-'14, Pres. '14-'16, Ex. Com. '20-'23), Professor of Anatomy and Director of the Anatomical Laboratories, Dean of the Graduate School, *University of Michigan, 1330 Hill St., Ann Arbor, Mich.*
- HUGHSON, WALTER, S.B., M.D., Associate in Research Otolaryngology, Assistant Visiting Surgeon, *Johns Hopkins Hospital, 1411 Eutaw Place, Baltimore, Md.*
- HUMPHREY, RUFUS R., A.B., A.M., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Buffalo, 24 High St., Buffalo, N. Y.*
- HUNT, THOMAS E., Ph.D., Assistant Professor of Anatomy, *University of Alabama Medical School, University, Ala.*
- HUNTER, OSCAR B., A.B., A.M., M.D., Assistant Dean and Professor of Pathology and Bacteriology, *George Washington Medical School, 1335 H St., N.W., Washington, D. C.*
- HUNTER, RICHARD HENRY, Ph.D., M.D., M.Ch., F.Z.S., Senior Lecturer in Anatomy, *Department of Anatomy, Queen's University, Belfast, Ireland.*
- INGALLS, N. WILLIAM, B.S., M.D., Associate Professor of Anatomy, *School of Medicine, Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.*
- INGRAM, W. R., Ph.D., Associate in Neurology, *Northwestern University Medical School, Institute of Neurology, 303 E. Chicago Ave., Chicago, Ill.*
- INGVAR, SVEN, M.D., Professor of Internal Medicine, *University of Lund, Lund, Sweden.*
- JACKSON, CLARENCE M., M.S., M.D., LL.D. (Ex. Com. '10-'14, '23-'28, Vice-Pres. '16-'17, Pres. '22-'23), Professor and Director of the Department of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*
- JENKINS, GEORGE B., M.D., Professor of Anatomy and Director of Anatomy Department, *George Washington University Medical School, Washington, D. C.*
- JOB, THESLE T., A.B., M.S., Ph.D., Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*
- JOHNSON, CHARLES EUGENE, A.M., Ph.D., Head of Department and Professor of Zoölogy and Director of the Roosevelt Wild Life Forest Experiment Station, *Department of Forest Zoölogy, State College of Forestry, Syracuse, N. Y.*

- JOHNSON, FRANKLIN P., A.M., Ph.D., M.D., Assistant Professor of Urology, University of Oregon Medical School, *316 Medical Arts Building, Portland, Ore.*
- JOHNSON, SYDNEY E., Ph.D., M.D., Professor of Gross Anatomy, School of Medicine, University of Louisville, *101 West Chestnut St., Louisville, Ky.*
- JOHNSTON, JOHN B., Ph.D., Dean of the College of Science, Literature and the Arts, Professor of Comparative Neurology, *University of Minnesota, Minneapolis, Minn.*
- JOHNSTON, THOMAS BAILLIE, M.B., Ch.B., Professor of Anatomy, University of London, *Guy's Hospital Medical School, London, S. E. 1, England.*
- JOHNSTONE, PAUL N., A.B., M.D., *601 Lathrop Building, Kansas City, Mo.*
- JORDAN, HARVEY ERNEST, A.M., Ph.D. (Ex. Com. '18-'21), Professor of Histology and Embryology, *Department of Medicine, University of Virginia, Charlottesville, Va.*
- KAAH, HELEN WARTON, Ph.D., Assistant Professor of Zoölogy, *Wellesley College, Wellesley, Mass.*
- KAMPMEIER, OTTO FREDERIC, A.B., Ph.D., M.D., Professor of Anatomy, *College of Medicine, University of Illinois, 1853 West Polk Street, Chicago, Ill.*
- KAPPERS, CORNELIUS URBO ARIËNS, M.D., Director of the Central Institute for Brain Research of Holland; Professor of Comparative Neurology, University of Amsterdam, *Mauritskade 61, Amsterdam, Holland.*
- KEEGAN, J. JAY, A.M., M.D., Professor of Neurological Surgery, University of Nebraska College of Medicine, *1520 Medical Arts Building, Omaha, Neb.*
- KEITH, ARTHUR, M.D., LL.D., F.R.C.S., F.R.S., Hunterian Professor of Anatomy, *Royal College of Surgeons, Lincoln's Inn Fields, London, W. C. 2, England.*
- KELLOGG, HOWARD BUTTERS, B.S., M.S., Ph.D., M.D., Associate Medical Officer U.S.V.B., Department of Surgery, Edward Hines Hospital, Hines, Illinois, *1918 South 7th Ave., Maywood, Ill.*
- KELLOGG, REMINGTON, Ph.D., Assistant Curator of Mammals, *U. S. National Museum, Washington, D. C.*
- KELLY, G. LOMBARD, A.B., B.S., M.D., Professor of Anatomy, *University of Georgia, Medical Department, Augusta, Georgia.*
- KERNAN, JOHN D., JR., A.B., M.D., Associate Professor of Oto-Laryngology, Columbia College of Physicians and Surgeons, *120 East Seventy-fifth St., New York City.*
- KERR, ABRAHAM T., B.S., M.D. (Ex. Com. '10-'14), Professor of Anatomy and Secretary of Cornell University Medical School, *Cornell University Medical College, Ithaca, N. Y.*
- KEY, J. ALBERT, B.S., M.D., Director of Research, *Shriner's Hospital for Crippled Children, St. Louis, Mo.*
- KINDRED, JAMES ERNEST, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, *University of Virginia Medical School, University, Va.*
- KING, HELEN DEAN, A.M., Ph.D., Member of The Wistar Institute (Experimental Zoölogy), *The Wistar Institute of Anatomy, 36th St. and Woodland Ave., Philadelphia, Pa.*
- KING, JESSIE L., Ph.D., Professor of Physiology, *Goucher College, Baltimore, Md.*
- KINGERY, HUGH McMILLAN, A.B., A.M., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Colorado, Denver, Col.*

- KINGSBURY, BENJAMIN F., A.B., Ph.D., M.D. (Ex. Com. '22-'25, Vice-Pres. '32-), Professor of Histology and Embryology, Cornell University, 2 South Ave., Ithaca, N. Y.
- KIRKHAM, WILLIAM BARRE, Ph.D., Consulting Director, Museum of Natural History, 275 Maple St., Springfield, Mass.
- KNOUFF, R. A., B.A., M.A., Ph.D., Associate Professor of Anatomy, Department of Anatomy, Ohio State University, Columbus, Ohio.
- KNOWER, HENRY MCE., A.B., Ph.D. (Ex. Com. '11-'15, '24-'26), Associate Professor of Anatomy, Albany Medical College, Albany, N. Y.
- KOCH, JOHN C., B.S., M.D., Junior Physician, Harper Hospital, 265 Euclid Ave., East, Detroit, Mich.
- KOFOID, CHARLES ATWOOD, A.B., Ph.D., Sc.D., Professor of Zoölogy and Chairman of Department, Room 4079, Life Science Bldg., University of California, Berkeley, Calif.
- KORNHAUSER, S. I., M.A., Ph.D., Professor of Anatomy and Executive Secretary, University of Louisville, Medical School, Louisville, Ky.
- KRAFKA, JOSEPH, JR., Ph.D., Associate Professor of Anatomy, Medical Department, University of Georgia, Augusta, Ga.
- KRAUSE, ALLEN KRAMER, A.B., A.M., M.D., President and Director, The Desert Sanatorium, Tucson, Arizona.
- KROGMAN, WILTON M., Ph.D., Associate Professor of Physical Anthropology, Western Reserve University, Cleveland, Ohio.
- KUDO, TOKUYASU, M.D., Professor of Anatomy and Histology, Niigata Medical College, Niigata City, Echigo, Japan.
- KUNITOMO, KANAE, M.D., Professor of Anatomy, Anatomical Institute, Nagasaki Medical School, Nagasaki, Japan.
- KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D., Professor of Biology, Lafayette College, Easton, Pa.
- KUNTZ, ALBERT, Ph.D., M.D., Professor of Micro-anatomy, St. Louis University Medical School, 1402 South Grand Ave., St. Louis, Mo.
- KUTCHIN, MRS. HARRIET LEHMANN, A.M., "The Maplewood," Green Lake, Wis.
- LAMBERT, AVERY ELDORUS, B.S., Ph.D., Professor of Histology, State University of Iowa Medical School, Room 360, Medical Laboratories Bldg., Iowa City, Iowa.
- LANDACRE, FRANCIS LEROY, Ph.D., Professor of Anatomy and Head of Department, Ohio State University, 2026 Inka Ave., Columbus, Ohio.
- LANGWORTHY, OETHELLO R., A.B., A.M., M.D., Associate in Neurology, Johns Hopkins University, Johns Hopkins Hospital, Baltimore, Md.
- LARSELL, OLOF, A.M., Ph.D., Professor of Anatomy, University of Oregon Medical School, Portland, Oregon.
- LATIMER, HOMER B., A.M., Ph.D., Professor of Anatomy, Medical School, University of Kansas, Lawrence, Kansas.
- LATTA, JOHN S., A.B., Ph.D., Professor of Anatomy, University of Nebraska, College of Medicine, Forty-second St. and Dewey Ave., Omaha, Neb.
- LEE, FERDINAND CHRISTIAN, A.B., M.D., Associate in Surgery, Johns Hopkins Hospital, Baltimore, Md.
- LEE, THOMAS G., B.S., M.D. (Ex. Com. '08-'10, Vice-Pres. '12-'14), Emeritus Professor of Comparative Anatomy, Institute of Anatomy, University of Minnesota, Babson Park, Florida.

- LEIDY, JOSEPH, JR., A.B., A.M., M.D., formerly Assistant Demonstrator of Anatomy, University of Pennsylvania, Officier de l'instruction publique de France, 1713 Walnut St., Philadelphia, Pa.
- LEVI, GIUSEPPE, M.D., Professor of Anatomy, *University of Torino, Istituto anatomico, Corso d'Azeglio 52, Torino, Italy.*
- LEWIS, DEAN D., M.D., Sc.D., LL.D., Professor of Surgery, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*
- LEWIS, FREDERIC T., A.M., M.D. (Ex. Com. '09-'13, Vice-Pres. '14-'16), Professor of Comparative Anatomy, *Harvard Medical School, Boston, Mass.*
- LEWIS, MARGARET REED, M.A., Research Associate, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*
- LEWIS, WARREN HARMON, B.S., M.D. (Ex. Com. '09-'11, '14-'17), Research Associate, Department of Embryology, Carnegie Institution, Professor of Physiological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- LILLIE, FRANK RATTRAY, Ph.D., Sc.D., Professor of Embryology, Chairman of Department of Zoölogy, University of Chicago; Director Marine Biological Laboratory, Woods Hole, Mass., *University of Chicago, Chicago, Ill.*
- LINEBACK, PAUL EUGENE, A.M., M.D., Professor of Micro-anatomy, *Atlanta Medical College, Emory University, Ga.*
- LINELL, ERIC AMBROSE, Ch.B., M.D., Professor of Neuropathology, *Banting Institute, University of Toronto, Canada.*
- LIPSCHUTZ, BENJAMIN, M.D., Associate in Neuro-anatomy, Jefferson Medical College, 1007 Spruce St., *Philadelphia, Pa.*
- LITTLE, CLARENCE COOK, B.A., M.S., Sc.D., LL.D., *Jackson Memorial Laboratory, Bar Harbor, Maine.*
- LOOPER, JAMES BURDINE, B.S., M.S., Ph.D., Associate Professor of Histology and Embryology, *Box 55, University of Mississippi, University, Miss.*
- LORD, FREDERIC P., A.B., M.D., Professor of Anatomy, *Dartmouth Medical School, 39 College St., Hanover, N. H.*
- LOTH, EDWARD, M.D., Ph.D., Professor of Anatomy and Director of Anatomical Institute, University of Warsaw, *5 Chalubinski Str., Warsaw, Poland.*
- LOWREY, LAWSON GENTRY, A.M., M.D., Director, Institute for Child Guidance, *9th Floor, 145 East 57th Street, New York City.*
- LUCAS, MIRIAM SCOTT, Ph.D., Instructor in Cytology, *Washington University School of Medicine, St. Louis, Mo.*
- MACCALLUM, DANIEL BARTLETT, S.B., Ph.D., M.D., Associate Professor of Anatomy, *University of Southern California Medical School, Los Angeles, Calif.*
- MACFARLAND, FRANK MACE, A.M., Ph.D., Professor of Histology, Leland Stanford Junior University, *775 Santa Ynez Street, Stanford University, Calif.*
- MCCLENDON, JESSE F., Ph.D., Professor of Physiological Chemistry, University of Minnesota, *815 Fulton St. S. E., Minneapolis, Minn.*
- MCCCLUNG, CLARENCE E., Ph.G., A.B., A.M., Ph.D., Professor of Zoölogy and Director of the Zoölogical Laboratory, *University of Pennsylvania, Philadelphia, Pa.*
- MCCCLURE, CHARLES FREEMAN WILLIAMS, A.M., Sc.D. (Vice-Pres. '10-'11, Ex. Com. '12-'16, Pres. '20-'21), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

- MCCOTTER, ROLLO E., M.D., Professor of Anatomy, Medical Department, University of Michigan, 1043 Ferdon Road, Ann Arbor, Mich.
- MACEWEN, EWEN, M.D., Professor of Anatomy, University of Iowa, Iowa City, Iowa.
- McFALL, CLAUDE M., Ph.D., Assistant Professor of Biology, School of Histology and Embryology, University of Virginia, Charlottesville, Va.
- MCGILL, CAROLINE, A.B., A.M., Ph.D., M.D., Physician, 58 W. Quartz, Butte, Mont.
- McKIBBEN, PAUL S., Ph.D., LL.D. (Ex. Com. '31-), Professor of Anatomy, University of Southern California, Los Angeles, Calif.
- McKINNEY, ROSCOE L., Ph.D., Professor of Anatomy, Howard University, Washington, D. C.
- McMURRICH, JAMES PLAYFAIR, A.M., Ph.D., LL.D. (Ex. Com. '06-'07, '17-'20, Pres. '08-'09), Professor Emeritus of Anatomy, University of Toronto, Toronto, Canada.
- McNUTT, G. W., D.V.M., Assistant Professor of Veterinary Anatomy, College of Veterinary Medicine, Washington State College, Pullman, Wash.
- MACKLIN, C. C., M.B., M.D., M.A., Ph.D., F.R.S.C. (Ex. Com. '28-'32), Professor of Histology and Embryology, University of Western Ontario Medical School, London, Ontario, Canada.
- MAGATH, THOMAS BYRD, M.S., Ph.D., M.D., Consulting Physician, Clinical Laboratories, Mayo Clinic, and Associate Professor of Pathology, University of Minnesota, Mayo Clinic, Rochester, Minn.
- MAINLAND, DONALD, M.B., Ch.B., D.Sc., Department of Anatomy, Dalhousie University, Halifax, Nova Scotia, Canada.
- MALONE, EDWARD F., A.B., M.D. (Ex. Com. '31-), Francis Brunning Professor of Anatomy, University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.
- MANGUM, CHARLES S., A.B., M.D., Professor of Anatomy, University of North Carolina, 510 East Franklin St., Chapel Hill, N. C.
- MARK, EDWARD LAURENS, Ph.D., LL.D., Hersey Professor of Anatomy (Emeritus), Harvard University, and Trustee of the Bermuda Biological Station for Research, 109 Irving St., Cambridge, Mass.
- MARKEE, J. E., Ph.D., Assistant Professor of Anatomy, Stanford University, Stanford, Calif.
- MASON, KARL E., Ph.D., Associate Professor of Anatomy, Vanderbilt University Medical School, Nashville, Tenn.
- MASTIN, EDWARD V., M.S., M.D., Instructor in Anatomy, Washington University, 908 Beaumont Medical Bldg., St. Louis, Mo.
- MATAS, RUDOLPH, M.D., LL.D., Emeritus Professor of Surgery and Demonstrator of Anatomy, Tulane University of Louisiana, 2255 St. Charles Ave., New Orleans, La.
- MATTHEWS, SAMUEL A., M.A., Ph.D., Medical Associate in Anatomy, University of Pennsylvania, School of Medicine, Philadelphia, Pa.
- MATTINGLY, MARIE DEES, A.B., B.S., M.D., Assistant Professor of Anatomy, Tulane University of Louisiana, New Orleans, La.
- MAVOR, JAMES WATT, B.A., M.A., Ph.D., Professor of Biology, Union College, Schenectady, N. Y.
- MEAD, HAROLD TUPPER, B.A., M.S., Professor of Zoölogy, Hartwick College, Oneonta, N. Y.

- MEAKER, SAMUEL R., A.B., M.D., M.R.C.S. (Eng.), F.A.C.S., Professor of Gynaecology, Boston University School of Medicine, 475 Commonwealth Ave., Boston, Mass.
- MEYER, ADOLF, M.D., LL.D., Professor of Psychiatry and Director of the Phipps Psychiatric Clinic, *Johns Hopkins Hospital, Baltimore, Md.*
- MEYER, ARTHUR W., S.B., M.D. (Ex. Com. '12-'16, Vice-Pres. '24-'25), Professor of Anatomy, Leland Stanford Junior University, 121 Waverly St., Palo Alto, Calif.
- MICHELS, NICHOLAS A., M.A., D.Sc., Associate Professor of Anatomy, *The Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pa.*
- MILLER, ADAM M., A.M., Dean and Professor of Anatomy, Long Island College of Medicine, 350 Henry St., Brooklyn, N. Y.
- MILLER, SHIRLEY P., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *Anatomical Institute, University of Minnesota, Minneapolis, Minn.*
- MILLER, WILLIAM SNOW, M.D., Sc.D. (Vice-Pres. '08-'09), Professor of Anatomy (Emeritus), University of Wisconsin, 2001 Jefferson St., Madison, Wis.
- MOODY, ROBERT ORTON, B.S., M.D., Associate Professor of Anatomy, University of California, 2826 Garber St., Berkeley, Calif.
- MOORE, CARL R., A.M., Ph.D., Professor of Zoölogy, *Hull Zoölogical Laboratory, University of Chicago, Chicago, Ill.*
- MORGAN, LAWRENCE ONIS, A.B., A.M., Ph.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*
- MORRILL, CHARLES V., A.M., Ph.D., Associate Professor of Anatomy, *Cornell University Medical School, First Ave. and Twenty-eighth St., New York City.*
- MORTON, DUDLEY JOY, M.D., Associate Professor, Department of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*
- MOSSMAN, HARLAND W., Ph.D., Assistant Professor of Anatomy, *Science Hall, University of Wisconsin, Madison, Wis.*
- MULL, PHILIP L., B.S., M.D., Dean, Professor of Anatomy, *University of Mississippi Medical School, Box 102, University, Miss.*
- MURRAY, WILLIAM S., B.A., M.A., Sc.D., Research Associate, Roscoe B. Jackson Memorial Laboratory, Box 148, Bar Harbor, Maine.
- MYERS, BURTON D., A.M., M.D., Professor of Anatomy and Dean of the Indiana University School of Medicine, 424 N. Walnut St., Bloomington, Ind.
- MYERS, J. ARTHUR, M.S., Ph.D., M.D., Professor of Preventive Medicine and Chief of Chest Clinic, *University of Minnesota Medical School, Minneapolis, Minn.*
- MYERS, MAE LICHTENWALNER, M.D., Professor of Histology and Embryology, Woman's Medical College of Pennsylvania, Henry Ave. and Abbottsford Rd., East Falls, Philadelphia, Pa.
- NACHTRIEB, HENRY FRANCIS, B.S., Professor Emeritus, Animal Biology, University of Minnesota, 2448 Cedar St., Berkeley, Calif.
- NAÑAGAS, JUAN CANCIO, M.D., Professor of Anatomy, College of Medicine, University of the Philippines, 719 Florida St., Manila, Philippine Islands.
- NEAL, HERBERT VINCENT, A.M., Ph.D., Sc.D., Professor of Zoölogy, Tufts College, Tufts College, 57, Mass.

- NICHOLAS, JOHN SPANLER, M.S., Ph.D., Assistant Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*
- NOBACK, GUSTAVE J., B.S., M.A., Ph.D., Professor of Anatomy, New York University, *338 East Twenty-sixth St., New York City.*
- NOBLE, GLADWIN K., A.B., M.A., Ph.D., Curator, Department of Herpetology and Experimental Biology, *American Museum of Natural History, 77th Street and Central Park West, New York City.*
- NONIDEZ, JOSÉ F., M.S., Sc.D., Assistant Professor of Anatomy, Cornell University Medical College, *477 First Ave., New York City.*
- NORRIS, H. W., A.B., Sc.D., Research Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*
- OBNCHAIN, JEANETTE B., Ph.D., Research Associate, Department of Anatomy, *University of Chicago, Chicago, Ill.*
- O'DONOGHUE, CHARLES H., D.Sc., F.Z.S., Lecturer, *Department of Zoölogy, University of Edinburgh, Scotland.*
- OKAJIMA, K., M.D., Professor of Anatomy, *Keio University Medical College, Yotsuya, Tokio, Japan.*
- O'LEARY, JAMES L., Ph.D., M.D., Assistant Professor of Cytology, *Washington University School of Medicine, St. Louis, Mo.*
- OSTERUD, HJALMAR L., A.B., A.M., Ph.D., Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*
- OVERHOLSER, MILTON D., A.B., A.M., Ph.D., Instructor, *Department of Anatomy, University and Bellevue Hospital Medical College, New York University, 338 East Twenty-sixth St., New York City.*
- PAINTER, THEOPHILUS S., Ph.D., Professor of Zoölogy, *Department of Zoölogy, University of Texas, Austin, Texas.*
- PALMER, CARROLL E., M.A., Ph.D., M.D., Instructor, *Department of Biostatistics, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.*
- PAPANICOLAOU, GEORGE N., Ph.D., M.D., Assistant Professor of Anatomy, *Cornell University Medical College, Twenty-eighth St. and First Ave., New York City.*
- PAPEZ, JAMES WENCESLAS, B.A., M.D., Assistant Professor of Anatomy and Neurology, *Cornell University Medical College, Ithaca, N. Y.*
- PARKER, GEORGE HOWARD, D.Sc., Professor of Zoölogy and Director of Zoölogical Laboratory, *Harvard University, 16 Berkeley St., Cambridge, Mass.*
- PATON, STEWART, A.B., M.D., *The Warrington Apartments, 3908 N. Charles St., Baltimore, Md.*
- PATTEN, BRADLEY MERRILL, A.M., Ph.D., Associate Professor of Histology and Embryology, *School of Medicine, Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.*
- PATTEN, WILLIAM, Ph.D., D.Sc., Professor Emeritus of Zoölogy, *Dartmouth College, Hanover, N. H.*
- PATTERSON, JOHN THOMAS, B.S., Ph.D., Professor of Zoölogy, *University of Texas, 1908 Cliff St., Austin, Texas.*
- PERKINS, ORMAN C., A.B., A.M., M.D., F.A.C.P., Professor of Neurology, *Long Island College of Medicine, 829 Carroll St., Brooklyn, N. Y.*
- PIERSOL, WILLIAM HUNTER, B.A., M.B., Professor of Histology and Embryology, *University of Toronto, 35 Dunvegan Road, Toronto, Canada.*

- POHLMAN, AUGUSTUS G., M.D. (Ex Com. '32-), Professor of Anatomy, St. Louis University, School of Medicine, *1402 South Grand Ave., St. Louis, Mo.*
- POLJAK, STEPHEN, M.D., Associate Professor of Neurology, Department of Medicine, *University of Chicago, Chicago, Ill.*
- POTTER, PETER, M.S., M.D., Oculist and Aurist, *Motor Clinic Bldg., Butte, Montana.*
- POYNTER, CHARLES W. M., B.S., M.D. (Ex. Com. '19-'22), Professor of Anatomy, and Dean of the College of Medicine, University of Nebraska, *Forty-second and Dewey Ave., Omaha, Neb.*
- PRATT, JEAN PAUL, M.D., Surgeon in Charge of Division of Gynecology and Obstetrics, *Henry Ford Hospital, Detroit, Mich.*
- PRYOR, JOSEPH WILLIAM, M.D., Emeritus Professor of Anatomy and Physiology, University of Kentucky, *417 West Second St., Lexington, Ky.*
- RADASCH, HENRY E., M.S., M.D., Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, Eleventh and Clinton Sts., Philadelphia, Pa.*
- RANSON, STEPHEN W., M.D., Ph.D. (Ex. Com. '21-'24, Vice-Pres. '26-'28), Professor and Director of Neurological Institute, Northwestern University Medical School, *303 East Chicago Ave., Chicago, Ill.*
- RASMUSSEN, ANDREW T., Ph.D., Professor of Neurology, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*
- RAVEN, HENRY C., B.A., Associate Curator, Department of Comparative and Human Anatomy, *American Museum of Natural History, Seventy-seventh St. and Central Park West, New York City.*
- RAWLINSON, HERBERT E., M.B., Instructor in Histology and Embryology, *McGill University, Montreal, Canada.*
- REAGAN, FRANKLIN P., Ph.D., Associate Professor of Anatomy, Medical School, University of Illinois, *1853 West Polk St., Chicago, Ill.*
- REED, HUGH D., B.S., Ph.D., Professor of Zoölogy, Cornell University, *McGraw Hall, Ithaca, N. Y.*
- DE RÉNYI, GEORGE ST., M.D., Associate Professor of Anatomy, University of Pennsylvania, School of Medicine, *214 South 46th St., Philadelphia, Pa.*
- REVELL, DANIEL GRAISBERRY, A.B., M.B., Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*
- RHINEHART, D. A., A.M., M.D., Professor of Applied Anatomy, University of Arkansas, *4 Armistead Rd., Little Rock, Ark.*
- RICE, EDWARD LORANUS, A.B., Ph.D., Sc.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware, Ohio.*
- RIENHOFF, WILLIAM F., JR., A.B., M.D., Assistant Visiting Surgeon, Johns Hopkins Hospital, *1201 North Calvert St., Baltimore, Md.*
- RINGOEN, ADOLPH R., A.M., Ph.D., Associate Professor of Zoölogy, *Department of Zoölogy, University of Minnesota, Minneapolis, Minn.*
- RIOCH, DAVID MCK., A.B., M.D., Assistant Professor of Anatomy, *Harvard Medical School, Boston, Mass.*
- ROBERTSON, ALBERT DUNCAN, B.A., M.A., Professor of Zoölogy, *Western University, London, Ontario, Canada.*
- ROBINSON, BYRON L., M.A., M.D., Professor of Anatomy, *University of Arkansas Medical School, Little Rock, Ark.*

- ROGERS, JAMES B., A.M., M.D., Assistant Professor of Anatomy, *University of Louisville, School of Medicine, Louisville, Kentucky.*
- ROGERS, WILLIAM MITCHELL, B.S., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*
- ROMER, ALFRED S., B.A., Ph.D., Professor of Vertebrate Palaeontology, *Walker Museum, University of Chicago, Chicago, Ill.*
- RUPERT, R. R., M.D., Suite 416-417 Dalziel Bldg., 532 Fifteenth St., Oakland, Calif.
- RUTH, EDWARD S., M.D., F.A.C.S., Associate Surgeon, Children's Hospital, Los Angeles; 922 Taft Bldg., Hollywood, Calif.
- SABIN, FLORENCE R., B.S., M.D., Sc.D., LL.D. (Second Vice-Pres. '08-'09, Pres. '24-'25), Member of Rockefeller Institute, *Rockefeller Institute for Medical Research, Sixty-sixth St. and York Ave., New York City.*
- SACHS, ERNEST, A.B., M.D., Professor of Clinical and Neurological Surgery, *Washington University School of Medicine, 519 University Club Bldg., St. Louis, Mo.*
- SANTEE, HARRIS E., A.M., Ph.D., M.D., Neurologist, *R. F. D., Box 72, West Chicago, Ill.*
- SCAMMON, RICHARD E., Ph.D. (Ex. Com. '23-'26, Vice-Pres. '28-'30), Dean of Medical Sciences, *University of Minnesota, Minneapolis, Minn.*
- SCHAEFFER, JACOB PARSONS, A.M., M.D., Ph.D., Sc.D. (Ex. Com. '24-'29), Professor of Anatomy and Director of the Daniel Baugh Institute of Anatomy, *Jefferson Medical College, 4634 Spruce St., Philadelphia, Pa.*
- SCHNEIDER, ANTOINE J., M.D., *Boston City Hospital, Boston, Mass.*
- SCHOCHET, SYDNEY S., M.D., Surgeon, *55 East Washington St., Chicago, Ill.*
- SCHOEMAKER, DANIEL M., B.S., M.D., Professor of Anatomy, Medical Department, *St. Louis University, 1402 South Grand Ave., St. Louis, Mo.*
- SCHULTE, HERMANN VON W., A.B., M.D. (Ex. Com. '15-'18), Professor of Anatomy and Dean, *Creighton University School of Medicine, 306 North Fourteenth St., Omaha, Neb.*
- SCHULTZ, ADOLPH H., Ph.D., Associate Professor of Physical Anthropology, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- SCHWIND, JOSEPH L., A.B., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical College, First Ave. and 28th St., New York City.*
- SCOTT, GORDON H., Ph.D., Associate Professor of Cytology, *Washington University School of Medicine, St. Louis, Mo.*
- SCOTT, JOHN W., A.B., A.M., Ph.D., Professor of Zoölogy and Director of Pre-Medical Curriculum, *University of Wyoming, Laramie, Wyoming.*
- SELLING, LAWRENCE, A.B., M.D., Clinical Professor of Medicine, *University of Oregon Medical School, Mayer Building, Portland, Ore.*
- SENIOR, H. D., M.D., D.Sc., F.R.C.S. (Vice-Pres. '22-'23), Professor of Anatomy, *New York University and Bellevue Hospital Medical College, 338 East Twenty-sixth St., New York City.*
- SEVERINGHAUS, AURA E., B.S., M.A., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, New York City.*
- SHANER, RALPH FAUST, Ph.D., Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

- SHARP, CLAYTON, M.D., Assistant Professor of Anatomy, Hoagland Laboratory, Long Island College of Medicine, *335 Henry St., Brooklyn, New York.*
- SHEARER, EDWIN M., Ph.D., Assistant Professor of Anatomy, New York University and Bellevue Hospital Medical College, *Twenty-sixth St. and First Ave., New York City.*
- SHEININ, JOHN J., B.S., M.S., Department of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*
- SHELLSHEAR, JOSEPH LEXDEN, M.B., Ch.M., Professor of Anatomy, *University of Hongkong, Hongkong, China.*
- SHIELDS, RANDOLPH TUCKER, A.B., M.D., Professor of Histology and Embryology, School of Medicine, *Shantung Christian University, Tsinan, Shantung, China.*
- SHIMIDZU, YOSHITAKA, M.D., Professor of Gynecology, *Nagasaki Medical College, Nagasaki, Japan.*
- SHUMWAY, WALDO, A.B., A.M., Ph.D., Professor of Zoölogy, *University of Illinois, Urbana, Ill.*
- SIMKINS, CLEVELAND S., A.B., Ph.D., Associate Professor of Anatomy and Embryology, University of Tennessee Medical School, *875 Monroe Ave., Memphis, Tenn.*
- SIMPSON, MIRIAM ELIZABETH, A.B., M.S., Ph.D., M.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*
- SMITH, BERTRAM GARNER, A.B., Ph.D., Professor of Anatomy, New York University and Bellevue Hospital Medical College, *338 East 26th St., New York City.*
- SMITH, CHRISTIANNA, A.M., Ph.D., Associate Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*
- SMITH, DAVID T., A.B., M.D., Associate Professor of Medicine, Duke University, *Duke Hospital, Durham, N. C.*
- SMITH, GEORGE MILTON, A.B., M.D., Attending Surgeon, St. Mary's and Waterbury Hospitals, *Pine Orchard, Conn.*
- SMITH, GRAFTON ELLIOT, M.A., M.D., F.R.S., Ch.M., D.Sc., Litt.D., F.R.C.P., Professor of Anatomy, *University College, Gower Street, London, W.C.1, England.*
- SMITH, H. P., A.B., M.S., M.D., Professor of Pathology, *University of Iowa School of Medicine, Iowa City, Iowa.*
- SMITH, PHILIP EDWARD, M.S., Ph.D., Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *632 West 163th St., New York City.*
- SMITH, WILBUR CLELAND, M.D., Professor of Gross Anatomy, *Tulane University, New Orleans, La.*
- SMITH, WILBUR K., A.B., M.D., Assistant Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*
- SNYDER, FRANKLIN FAUST, M.D., Assistant, Department of Obstetrics, *Johns Hopkins Hospital, Baltimore, Md.*
- SPAULDING, M. H., A.B., A.M., Professor of Zoölogy, University of Montana, *507 South Eighth Ave., Bozeman, Montana.*
- SPEIDEL, CARL C., Ph.B., Ph.D., Professor of Anatomy, University of Virginia, *University, Va.*
- STARK, MARY B., Ph.B., M.A., Ph.D., Professor of Histology and Embryology, New York Homeopathic Medical College and Flower Hospital, *450 East Sixty-fourth St., New York City.*

- STEVENSON, PAUL HUSTON, B.S., M.A., M.D., Associate Professor of Anatomy, *Peiping Union Medical College, Peiping, China.*
- STILES, HENRY WILSON, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *309 Orange St., Syracuse, N. Y.*
- STOCKARD, CHARLES RUPERT, M.D., M.S., Ph.D., Sc.D. (Sec. Treas. '14-'21, Ex. Com. '23-'28, Pres. '28-'30), Professor of Anatomy, Cornell University Medical College, *477 First Ave., New York City.*
- STONE, LEON STANSFIELD, Ph.B., Ph.D., Associate Professor of Anatomy, Yale School of Medicine, *Sterling Hall of Medicine, Anatomy Department, Cedar St., New Haven, Conn.*
- STONE, ROBERT S., B.A., M.A., M.B., M.D., Assistant Professor of Roentgenology, University of California, University Hospital, *Parnassus and Third Aves., San Francisco, Calif.*
- STOPFORD, JOHN SEBASTIAN B., M.D., Professor of Anatomy, *University of Manchester, Manchester, England.*
- STRAUS, WILLIAM L., JR., Ph.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*
- STREETER, GEORGE L., A.M., M.D., Sc.D. (Ex. Com. '18-'20, Pres. '26-'28), Director, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*
- STROMSTEN, FRANK ALBERT, B.S., M.S., D.Sc., Associate Professor of Zoölogy, State University of Iowa, *318 Zoölogy Building, Iowa City, Iowa.*
- STRONG, LEON H., Ph.D., Assistant Professor of Anatomy, Medical School, University of Michigan, *1008 E. Medical Building, University of Michigan, Ann Arbor, Mich.*
- STRONG, OLIVER S., A.B., A.M., Ph.D., Professor of Neurology and Neuro-histology, Columbia University, *College of Physicians and Surgeons, 630 West 168th St., New York City.*
- STRONG, REUBEN MYRON, A.B., A.M., Ph.D. (Ex. Com. '16-'19), Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*
- STUNKARD, H. W., Ph.D., Professor of Biology, *New York University, New York City.*
- SULLIVAN, WALTER EDWARD, A.M., Ph.D., Professor of Anatomy, University of Wisconsin, *Science Hall, Madison, Wis.*
- SUNDWALL, JOHN, Ph.D., M.D., Professor of Hygiene, Director of Hygiene, Public Health and Physical Education, University of Michigan, *619 East University Ave., Ann Arbor, Mich.*
- SUTTON, ALAN CALLENDER, A.B., M.D., Physician, *2124 N. Cascade Ave., Colorado Springs, Colo.*
- SWENSON, E. A., A.B., A.M., Ph.D., Instructor in Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Penna.*
- SWETT, FRANCIS HUNTINGTON, A.M., Ph.D., Professor of Anatomy, Duke University Medical School, *Box 3710, Durham, N. C.*
- SWIFT, CHARLES H., M.D., Ph.D., Associate Professor of Anatomy, *University of Chicago, Chicago, Ill.*
- SWINGLE, W. W., A.B., A.M., Ph.D., Professor of Biology, *Princeton University, Princeton, N. J.*

- SYKES, GEORGE F., Ph.B., M.A., Assistant Professor of Anatomy, Tufts College Medical School, 416 Huntington Ave., Boston, Mass.
- TERRY, ROBERT JAMES, A.B., M.D. (Ex. Com. '08-'12, '21-'24), Professor of Anatomy, Washington University School of Medicine, St. Louis, Mo.
- THOMPSON, IAN MACLAREN, B.Sc., M.B., Ch.B., Associate Professor of Anatomy, University of California, Berkeley, Calif.
- THOMSON, ARTHUR, M.A., M.B., LL.D., F.R.C.S., D.C.L., Professor of Anatomy, University of Oxford, Department of Human Anatomy, Oxford, England.
- THORKELSON, JACOB, M.D., 20 West Granite St., Butte, Mont.
- THRO, WILLIAM C., B.S., A.M., M.D., Professor of Clinical Pathology, Cornell University Medical College, Twenty-eighth St. and First Ave., New York City.
- THURINGER, JOSEPH M., M.D., Professor of Histology and Embryology and Head of Department, University of Oklahoma, School of Medicine, East 13th and Phillips Streets, Oklahoma City, Okla.
- TILNEY, FREDERICK, A.B., M.D., Ph.D., Professor of Neuro-Anatomy, Columbia University, Neurological Institute, Medical Center, New York City.
- TODD, T. WINGATE, M.B., Ch.B. (Manc.), F.R.C.S. (Eng.), (Vice-Pres. '20-'21, Ex. Com. '24-'29), Chairman and Director, Brush Foundation, Professor of Anatomy, Director of the Hamann Museum of Comparative Anthropology and Anatomy, Medical Department, Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.
- TOWER, SARAH SHELDON, B.S., Ph.D., M.D., Associate in Anatomy, Johns Hopkins Medical School, Baltimore, Md.
- TRACY, HENRY C., A.B., A.M., Ph.D., Professor of Anatomy, University of Kansas, Lawrence, Kansas.
- TROTTER, MILDRED, A.B., M.S., Ph.D., Associate Professor of Anatomy, Washington University School of Medicine, St. Louis, Mo.
- TURNER, CLARENCE L., M.A., Ph.D., Professor of Zoölogy, Northwestern University, Evanston, Ill.
- UHLENHUTH, EDUARD, Ph.D., Professor of Gross Anatomy, University of Maryland Medical School, Baltimore, Md.
- VAN CAMPENHOUT, ERNEST, M.D., Ph.D., Professor of Histology and Embryology, University of Montreal, Montreal, Canada.
- VAN DER HORST, C. J., D.Sc., Senior Lecturer in Zoölogy, University of Witwatersrand, P. O. Box 1176, Johannesburg, South Africa.
- VAN WAGENEN, GERTRUDE, A.B., Ph.D., Research Assistant in Obstetrics and Gynecology, Instructor's rank, Yale University, New Haven Hospital, New Haven, Conn.
- WAITE, FREDERICK CLAYTON, A.M., Ph.D., Professor of Histology and Embryology, Western Reserve University School of Medicine, 2109 Adelbert Road, Cleveland, Ohio.
- WALLIN, IVAN E., M.A., D.Sc., Professor of Anatomy and head of department, Secretary of Faculty, University of Colorado, School of Medicine, Denver, Colo.
- WALMSLEY, THOMAS, M.D., F.R.S.E., Professor of Anatomy, Queens University of Belfast, Belfast, Ireland.
- WATERSTON, DAVID, M.A., M.D., F.R.C.S., Ed., Bute Professor of Anatomy, University of St. Andrews, Bute Medical School, St. Andrews, Fife, Scotland.

- WATKINS, RICHARD WATKIN, S.B., M.D., Instructor in Otolaryngology, Rush Medical College, *5608 Kenwood Ave., Chicago, Ill.*
- WATT, JAMES CRAWFORD, M.A., M.D., Professor of Anatomy, University of Toronto, *20 Hawthorne Ave., Toronto, Canada.*
- WEATHERFORD, HAROLD LORRAINE, A.B., A.M., Ph.D., Assistant Professor of Histology, *Harvard Medical School, Boston, Mass.*
- WEBB, RICHARD L., A.B., M.S., Ph.D., Associate in Anatomy, *College of Medicine, University of Illinois, 1817 West Polk St., Chicago, Ill.*
- WEED, LEWIS HILL, A.B., A.M., M.D., Sc.D. (Ex. Com. '20-'21, Sec.-Treas. '22-'30), Professor of Anatomy and Director, *Johns Hopkins Medical School, Baltimore, Md.*
- WHEELER, THEODORA, A.B., M.D., *604 Fifth St., S. W., Rochester, Minn.*
- WHITESIDE-HARVEL, BEATRICE, B.A., Ph.D., Voluntary Research Worker, *Anatomisch-biologisches Institut der Universität, Berlin, Germany.*
- WHITNALL, S. E., M.A., M.D., B.Ch., M.R.C.R., L.R.C.P., Robert Reford Professor of Anatomy, *McGill University, Montreal, Canada.*
- WIEMAN, H. L., Ph.D., Professor of Zoölogy, *University of Cincinnati, Cincinnati, Ohio.*
- WILLARD, WILLIAM A., A.M., Ph.D., Professor of Anatomy, University of Nebraska, *College of Medicine, Forty-second St. and Dewey Ave., Omaha, Neb.*
- WILLIAMS, GEORGE D., A.B., A.M., M.D., Ph.D., Assistant Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*
- WILLIAMS, ROY GRIFFIN, A.B., A.M., M.D., Instructor in Anatomy, *University of Pennsylvania School of Medicine, Philadelphia, Pa.*
- WILLIAMS, STEPHEN CULVER, Ph.D., Associate in Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*
- WILLIER, BENJAMIN HARRISON, Ph.D., Professor of Zoölogy, *University of Chicago, Chicago, Ill.*
- WILSON, JAMES THOMAS, M.A., M.B., LL.D., F.R.S., Professor of Anatomy, *University of Cambridge, Anatomy School, New Museums, Cambridge, England.*
- WILSON, LOUIS BLANCHARD, M.D., Director of Mayo Foundation, Professor of Pathology in the University of Minnesota Graduate School, Mayo Clinic, *Walnut Hill Farm, Rochester, Minn.*
- WINDLE, WILLIAM F., B.S., M.S., Ph.D., Associate Professor of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*
- WISLOCKI, GEORGE B., A.B., M.D., Parkman Professor of Anatomy, *Harvard Medical School, Boston, Mass.*
- WITHERSPOON, THOMAS CASEY, M.D., *15375 Via de las Olas, Pacific Palisades, Calif.*
- WITSCHI, EMIL, Ph.D., Professor of Zoölogy, *The State University of Iowa, Iowa City, Iowa.*
- WITTENBORG, A. H., M.D., Professor of Anatomy, *College of Medicine, University of Tennessee, Memphis, Tenn.*
- WOLFE, JACK M., Ph.D., Instructor in Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*
- WOODMAN, ALICE S., M.D., Associate Professor of Histology and Embryology, *Boston University School of Medicine, 80 East Concord St., Boston, Mass.*

WOOLLARD, HERBERT H., M.D., Professor of Anatomy, *St. Bartholomew's Hospital Medical School, London, England.*

WORCESTER, JOHN LOCKE, M.D., Professor of Anatomy, University of Washington, *5211 Twenty-first Ave., N. E., Seattle, Wash.*

ZECHEL, GUSTAV, M.D., Associate in Anatomy and Surgery, University of Illinois College of Medicine, *1817 West Polk St., Chicago, Ill.*

ZIMMERMAN, ARNOLD, Ph.D., D.Sc. (Geneva, Switzerland), Assistant Professor of Anatomy, University of Illinois School of Medicine, *1853 West Polk St., Chicago, Ill.*

ZWEMER, RAYMUND L., A.B., Ph.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *630 West 168th St., New York City.*